FINAL REPORT

on the Project 19960498

Controlling Manure Odours from Swine Operations

A Demonstration and Education Project

Funded by Agri Food Innovation Fund (AFIF)

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Submitted by Lee Whittington
Prairie Swine Centre Inc.
P.O. Box 21057, 2105-8th St. East
Saskatoon, S7H 5N9

(P) 306-667-7447
(F) 306-955-2510
Whittington@sask.usask.ca

102-01826/

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EXECUTIVE SUMMARY

Introduction

During the period since the inception of the AFIF program the concern over the odour produced by the expansion of the swine industry in Saskatchewan has become increasingly problematic. The problem contains components of concern by pork producers who want to employ the latest techniques to minimize odour production and the general public (including neighbours) who need to be reassured that nuisance odour in the vicinity of intensive livestock units is minimal.

It is the objective of this project to address both of these areas of concern. Specifically, the project had the following objectives:

1. Use a multi-disciplinary approach and involve key industry information providers,
2. Produce written materials that would aid pork producers to reduce odours from manure,
3. Produce video information that addresses the issue with the target audience being the general public,
4. Conduct a tour of swine farms to demonstrate modern manure handling techniques. Target audience regulators, municipal councilors and media.

The project has produced one technical publication for pork producers and their advisors, ''Odour Management Technology for Pig Production Facilities'. This 21 page referenced publication provides an overview of current technologies for handling and treating manure and the odours emanating from it. A comprehensive literature search has produced over 140 references on research on the subject. Each reference has been reviewed and a summary prepared. Both of these documents are available to pork producers and others and are also made available on a web site maintained by the Centre (Environmental Issues Resource Centre).

The partners in the project conducted two very successful tours that exposed media, regulators and municipal councilors to the modern techniques used by pork producers to manage their effluent and minimize odours. In 1999 one partner, Pork Central, took the concept and with the financial assistance from the project, repeated the concept as a post-conference tour following the Manure Management '99 Conference in Saskatoon.

With the assistance of other partners who shared our concern for educating the general public on the subject. We produced a short video that interviews credible individuals across western Canada regarding the positive impact of the pork industry on their community. This video addresses directly the issue of odour and explains the caring and proactive approach used by pork producers to minimize this nuisance.

Through a large number of contributing partners who gave of their time and talents as well as their financial resources we were able to provide and distribute materials well beyond the scope of the original project. These partners also provided invaluable assistance in developing materials that were both accurate and that would be used by our

target audiences. The large number of partners did however slow the process and indeed the final version of the video was only made available in mid 2000.

The distribution of these materials is on going since each partner has a number of opportunities to utilize this information on a regular basis. In the case of the web-based database of scientific articles, the results of this project have been combined with another initiative (Environmental Issues Resource Centre) to ensure that the materials are available and updated on a regular basis.

The committee and the Prairie Swine Centre wish to acknowledge and thank the Agri-Food Innovation Fund for its support of this project.

Background

The hog industry in the prairie region of Western Canada has a competitive advantage over other Provinces and areas of the world with respect to cost, animal density, high herd health status and management expertise. These factors combined with moderate to good pork prices over the past ten years have lead many traditional as well as new entrants to expand their production. Expansion has included an increase in farm size. Typical new farm size is either 600 sow farrow to finish sites which are planned to expand to 1200 sows, or 2400+ sow SEW (Segregated Early Weaning) operations with 2400 sow space farrowing sites, 8800 pig space nursery sites and 8000 pig space feeder sites.

Saskatchewan has traditionally had a small hog industry relative to other provinces, and for many years has produced approximately 1 million finished hogs per year. These hogs were produced on more than 4000 farms 10 years ago. Today the number of pigs produced is rising and the number of farms raising those hogs is declining. This year production is expected to reach nearly 1.5 million head, all being produced on less than 1,500 farms. Less than 100 of today's producers account for more than 80% of these pigs. Projections indicate that 3 million hogs will be produced in Saskatchewan in 5 years time, and using a sustainable level of nutrient recycling the 'provinces arable land could support as many as 16 million finished hogs per year. Obviously there is substantial opportunity for growth provided the industry meets the expectations of society for what is considered 'sustainable' growth.

This small concentrated industry is not well understood by the rest of society in Saskatchewan or even by the rest of the agricultural industry in this Province. The hog industry has been negatively affected by headline grabbing "horror" stories from other jurisdictions. Technologies that directly address manure management, including odour control, have been developed here. These technologies and their effectiveness are not well known outside the industry. Consequently this project focuses on the need to make people aware of these developments. In short, it is the industry's responsibility to demonstrate that it is dealing effectively with one of the problems to expansion of pig numbers - Manure Odour.

Project Objectives

The project was conceived as a demonstration and education activity to maximize the effectiveness of the knowledge gained through research into the production, treatment, storage and handling of livestock manures and their odours. Through a series of communications activities the project sought to favourably influence production practices and public awareness and knowledge regarding the reduction and containment of swine manure odours.

This was to be accomplished using a variety of communications techniques including demonstration field trips, written communication, database development and video production. Specifically, the project had the following objectives:

- Use a multi-disciplinary approach and involve key industry information providers,
- Produce written materials that would aid pork producers to reduce odours from manure,
- Produce video information that addresses the issue with the target audience being the general public,
- Conduct a tour of swine farms to demonstrate modern manure handling techniques. Target audience regulators, municipal councilors and media.

Partners
The project was directed by a committee consisting of membership from:
Saskatchewan Agriculture and Food-Agricultural Operations Section, Mr. Bill Henley
Prairie Agricultural Machinery Institute (PAMI), Mr. Darrell Lischynski
Prairie Swine Centre Inc., Mr. Lee Whittington (project chair)

This group was responsible for developing the concepts, hiring summer students to assist in the project, developing all written materials and distribution of same. In 1998 Ms. Karen Bolton was asked to join the committee in her new capacity of Manure Management Specialist with Pork Central Branch of Saskatchewan Agriculture and Food. Karen also provided a significant link to other tri-provincial committees that were forming in the prairie provinces with mandates to address some of the same concerns and perceptions that our original project was addressing.

The project was fortunate to have been able to link to another group representing private business and government that wished also to develop a similar video. Our combined resources meant that unnecessary duplication was avoided and a more effective video could be produced. This partnership included:
Sunterra Farms, Acme, AB
Elanco Animal Health Products, Calgary, AB
Alberta Agriculture, Red Deer, AB
Manitoba Pork, Winnipeg, MB

This group shared equally in the financial development of the video ' Pork Production in Western Canada: – An Opportunity for Growth'.

Activities
Detailed activity reports are included in the two interim reports that have been included in the Appendix of this document. This report will serve to link all of those activities together and present the full breadth of the project's accomplishments.

Demonstration Farm Tours
Perhaps the component of the project that had the greatest impact to-date is the development of a series of tours during the summers of 1997 and 1998. This concept was selected by the committee developing the Manure Management '99 Conference in Saskatoon and a post-conference tour was conducted which was financially supported in part by this AFIF project. In total then there were three demonstration tours. Each tour had a different objective and target audience and focused on a different part of the province.

The 1997 Tour focused primarily on the media. Print, radio and TV were all represented, and to this day the images captured on this tour form the basis of the file footage frequently used for relevant pork industry stories. This in itself is a significant accomplishment as previously the images displayed were either significantly out of date or taken from news stories in other parts of the world and typically represented the worst possible environmental situation. The tour allowed researchers, extension personnel and

pork producers to discuss in a learning environment the progress being made in manure management and odour control. This phase of the project was designed to enlighten media to allow for fairer coverage in future stories.

The 1998 Tour moved from the Humboldt/Saskatoon area to the Regina/Belcarres area. This allowed a different set of journalists to join us, but our main target audience for this tour was municipal councilors. Councilors faced with the responsibility of approving building permits were becoming the target of much pressure by neighbours both for and against proposed intensive livestock projects. With little experience, and in many cases no staff planners, theses officials find it increasingly difficult to determine the validity of claims made by proponets and opponents to such development. This group benefited tremendously from the experience of standing beside an earthen manure storage, following a slurry injection applicator across the field, and just standing near and down-wind of a hog barn. Many of the candid comments of these people have been captured on the video.

In 1999 the tour returned to the Humboldt area and served local as well as regional and international guests of the Manure Management Conference by demonstrating crop growth from manure fertilization, earthen manure storage cover techniques and the latest in application technologies. More than 100 people participated in this tour, the largest of the three years.

Probably the most memorable moment from the tour occurred in 1997 when the tour culminated with a picnic lunch on the banks of a recently straw-covered earthen manure storage. The aroma of a home-cooked meal eclipsed the absence of noticeable pig odour. Even today, the participants from this event comment on the impact that one simple meal had on their perceptions of the industry. During the Saskatchewan Pork Industry Symposium in November 2000 I was participating on a media panel and this example was brought up by a member of the audience followed by an amazing level of recognition of this event still in the minds of many in attendance. Many of those in attendance had not directly participated in the tour but had seen the media coverage or spoken to others who had been on the tour.

The tours were evaluated by participant evaluation and review of media coverage following the event. These evaluations revealed that this type of activity needs to be repeated in other parts of the province as it rated very high as an education experience. The tours resulted in significant numbers of quotations that were very positive toward the industry such as those captured on the video or included in our first interim report. For example, Murray Lyons, a reporter with the Saskatoon Star Phoenix, discussing direct manure injection "If this system was widely used, I do not think there would be any objection to the distribution of hog manure".

Printed Materials

In influencing the speed of technology adoption, perhaps printed materials are still the best method. This media allows for detailed information to be transmitted and reviewed as often as is required to make a decision. For this reason printed materials were the

primary activity directed at pork producers and their advisors. The 21 page booklet "Odour Management technology for Pig Production Facilities" was produced to address the questions of pork producers. The booklet, which can be found in the Appendix of this report, provides an overview of the principle odour-causing activities on a hog farm. The manual sites the current scientific thinking in the areas of nutrition, siting and building considerations, manure treatments, and land application techniques.

No production document is complete without an analysis of cost versus benefit. With the benefits being very subjective we focused on the cost side of the equation regarding various manure management and odour-controlling technologies. This fully-referenced document attempts to evaluate competing technologies on a per animal housed basis so that adoption may be encouraged by providing easy to use analysis to allow pork producers to make economic decisions quickly.

The other printed materials focus on providing a one-stop source of verified scientific information on the subject. More than 140 papers have been reviewed and documented. This information provides not only the reference for future use but also a summary has been condensed from each article or journal paper so that the main points can be captured quickly. This component of the project serves not only pork producers, but researchers, policy makers and others all benefit from the condensed and easily accessed format.

Video Materials

The number of public meetings that are held in conjunction with the process for making application for establishing an intensive livestock unit has provided a unique public setting. These groups are typically ill-informed on the pork industry in general and have serious concerns about various aspects of environment. A video which provides factual information about the industry from an unbiased, science-based source was viewed by the industry to have significant value. With this in mind we set about producing a video on manure management and odour control.

Early in our planning we discovered another group had a similar project planned. We collaborated over the period of about two years to produce a video, which addressed the many issues surrounding the industry with special emphasis on providing clarity on environmental concerns. This resulted in an end product which is more thorough and more professional than we could have developed using only our committee's resources. Collaboration also meant that there would be one video shown at such meetings as we recognized early on that there would be little room in such public venues for more than one video. The wider collaboration also meant a larger group would eventually take ownership for distribution of the tapes long after the AFIF project committee ceased to function. Unfortunately this also meant that progress was very slow as people within our collaboration changed jobs and replacement members were added. This delay in video production of almost two years has been the primary reason for requested project extensions and a delay in final report submission.

Web-based Materials

During the development of this project a parallel project was developed at the Centre with broad-based industry support. The Environmental Issues Resource Centre took the concept of a thorough literature review to new heights by providing the summarized information in a database that could be easily accessed via the Internet. The work established in written form for the AFIF project was incorporated into the larger database and provides a unique information resource to the industry, government and the general public. This site can be easily accessed from the Prairie Swine web site at prairieswine.com or from any number of pork organizations which have links to it.

Through the use of searches generated by key words, or topic, the user can asses the scientific information available by reading short summaries of papers originally prepared for principally a scientific audience. Through the use of a glossary and an easy-to-read style all visitors can glean significant detail and conclusions from this information.

Conclusions

The project has succeeded through a unique series of partnerships to provide significant information resources, profile and media coverage for the issue, an on-going plan for maintenance and access to the information to the widest possible audience, and direct exposure to the industry's challenge for the media and decision makers in Saskatchewan. Due to the response we experienced, there may well be an on-going role for Pork Central or other group to continue to offer the tour portion of this project on a regular basis.

Environmental Issues Resource Centre
Odour Management

Reference No.	Title	Author(s)	Year	Reference	Country
	A Low Cost Balloon-Type Lagoon Cover	Zhang, Y. and W. Gakeer	1996	1996 Annual Research Report, Prairie Swine Centre Inc.	Canada
	A preliminary Assessment of Machines for Surface Spreading of Sludges and Slurries with Minimum Odour	Stroud, D.A. and V.R. Phillips	1988	Volatile Emissions from Livestock Farming and Sewage Operation. Edited by V.C. Nielsen, J.H. Voorburg and P. L'Hermite. p.103-112	UK
	A protocol for odour impact assessment	Nicell, J.A. and M.K. Tsakaloyannis.	1997	Proceedings of the 4th International Conference on Characterization and Control of Emissions of Odors and VOCs. October 20 to 22 1997. Montreal, Qc, Canada. p. 182-194	Canada, QC
	A Review of the Literature on the Nature and Control of Odors from Pork Production Facilities	Miner, J.R.	1995	Prepared for The Odor Subcommittee of the Environmental Committee of the National Pork Producers Council. 118 p.	U.S.A.
	Aerial Environment in Animal Housing. Concentration in and Emissions from Farm Buildings.	CIGR. International Commission of Agricultural Engineering.	1994	Working Group Report Series No 94.1.	
	Anaerobic Digestion - A Holistic Approach to Odor Control	Wilkie, A.C.	1997	In: Environmental Issues in Pork Production. The Allen D. Leman Swine Conference. September 20, 1997. Minnesota Extension Service. University of Minnesota. p. 30-36	U.S.A.
	Analyse olfactive : du nez humain au nez electronique. (Olfactive Analysis : from human nose to electronic nose)	Hermia, J.	1997	Proceedings of the 4th International Conference on Characterization and Control of Emissions of Odors and VOCs. October 20 to 22 1997. Montreal, Qc, Canada. p. 2-20	Canada, QC
	Assessment of the protection distance to avoid annoyance by odour sensation caused by livestock husbandry by Austrian guideline	Schauberger, G. (1) and M. Piringer (2)	1997a	Ammonia and Odour Control from Animal Production Facilities. Proceedings of the International Symposium. Vinkeloord, The Netherlands. October 6-10, 1997. p.677-684	Austria
	Biofilter/Wetscrubber Combinations for the Reduction of Ammonia, Odour and Dust Emissions of Pig Fattening Houses	Siemers, V. and H. Van den Weghe	1997	Ammonia and Odour Control from Animal Production Facilities. Proceedings of the International Symposium. Vinkeloord, The Netherlands. October 6-10, 1997. p.537-544	Germany
	Biofiltration System for Testing the Reduction of Odor from Swine Buildings	Young, J.S., J.J. Classen, R.W. Bottcher and P.W. Westerman	1997b	Ammonia and Odour Control from Animal Production Facilities. Proceedings of the International Symposium. Vinkeloord, The Netherlands. October 6-10, 1997. p.521-528	U.S.A.
	Characterisation hedonistique des odeurs par la mesure des reactions neurovegetatives (Odor hedonics caracteristics by autonomic responses measurements)	Robin, O. (2), O. Alaoui-Ismaili, J. Chanel (1), G. Delhomme, A. Dittmar (3), S. Rousmans (1) and E. Vernet-Maury (3)	1997	Proceedings of the 4th International Conference on Characterization and Control of Emissions of Odors and VOCs. October 20 to 22 1997. Montreal, Qc, Canada. p. 375-393	Canada, QC
	Characterisation of air extracted from pig [illegible] effects of the presence of slurry	Guingand, N. (1), R. Granier (2) and P. Massabie (2)	1997	Ammonia and Odour Control from Animal Production Facilities. Proceedings of the	France

Environmental Issues Resource Centre
Odour Management

Reference No.	Title	Author(s)	Year	Reference	Country
	and the ventilation rate.			International Symposium. Vinkeloord, The Netherlands. October 6-10, 1997. p.49-55.	
	Comparison of Hydrogen Sulfide and Odor Emissions from Animal Manure Storages	Jacobson, L.D., C.J. Clantont, D.R. Schmid, C. Radman, R.E. Nicolai and K.A. Janni	1997b	Ammonia and Odour Control from Animal Production Facilities. Proceedings of the International Symposium. Vinkeloord, The Netherlands. October 6-10, 1997. p.405-412.	U.S.A.
	Control of Manure Odors	ASEA, American Society of Agricultural Engineers	1997	ASEA EP379.1 DEC96. ASAE Standards 1997. Standards Engineering Practices Data. Reaffirmed for one year 1996. p. 642-643.	United States
	Control of Odours by Dietary Manipulation	Hobbs, P.J. (1), B.F. Pain (1), R.M. Kay (2) and P.A. Lee (2)	1997	Ammonia and Odour Control from Animal Production Facilities. Proceedings of the International Symposium. Vinkeloord, The Netherlands. October 6-10, 1997. p.267-272.	U.K.
	Controlling Manure Odor Emission Using Covers	Liu, X.W., D.S. Bundy, J. Zhuand M. Huss	1997	Livestock Environment V. Volume 1. Proceedings of the Fifth International Symposium. Edited by Robert W. Bottcher, Steven J. Hoff. Published by the American Society of Agricultural Engineering. St. Joseph, Michigan. 49085-9659. p. 322-328	U.S.A
	County Human Health Concerns from Air Pollution	Bruns, J.L.	1997	In: Environmental Issues in Pork Production. The Allen D. Leman Swine Conference. September 20, 1997. Minnesota Extension Service. University of Minnesota. p. 56-58	U.S.A.
	Deodorization of Swine Sewage by Addition of Phototropic Bacterium, Rhodopseudomonas capsulata	Lee, M.G. and M. Kobayashi	1992	Soil Science Plant Nutrition, 38, 767-770, 1992	Japan
	Desodorisation du lisier de porc par le procede de biofiltration sur support BIOSORmc (Swine manure deodorization by BIOSOR TM biofilter)	Buelna, G. (1), R. Dube (1), P. Lessard (2), F. Cotte (3), C. Gracian (3) and J.L. Fanlo (3)	1997	Proceedings of the 4th International Conference on Characterization and Control of Emissions of Odors and VOCs. October 20 to 22 1997. Montreal, Qc, Canada. p. 253-265	Canada, QC
	Determination of the Odor Plume Boundaries from Animal Houses	Hartung E. and T. Jungbluth	1997	Livestock Environment V. Volume 1. Proceedings of the Fifth International Symposium. Edited by Robert W. Bottcher, Steven J. Hoff. Published by the American Society of Agricultural Engineering. St. Joseph, Michigan. 49085-9659. p. 163-169	Germany
	Developing an Olfactometer for Livestock Odor Evaluation	Li, X.W., D.S. Bundy and S.J. Hoff	1997	Ammonia and Odour Control from Animal Production Facilities. Proceedings of the International Symposium. Vinkeloord, The Netherlands. October 6-10, 1997. p.155-160.	U.S.A
	Dust Effects on Odor and Odor Compounds	Hoff, S.J., D.S. Bundy and X.W. Li	1997a	Ammonia and Odour Control from Animal Production Facilities. Proceedings of the	U.S.A

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Reference No.	Title	Author(s)	Year	Reference	Country
				International Symposium. Vinkeloord, The Netherlands. October 6-10, 1997. p.101-110.	
	Ecosorb - Un neutralisant d'odeurs naturellement efficace	Denis, R.	1997	Proceedings of the 4th International Conference on Characterization and Control of Emissions of Odors and VOCs. October 20 to 22 1997. Montreal, Qc, Canada. p. 315-334	Canada, QC
	Electronic nose evaluation of synthetic hog farm odor.	Classen, J.J., S.S. Schiffman, H.T. Nagle and R. Gutierrez - Osuna	1997	Ammonia and Odour Control from Animal Production Facilities. Proceedings of the International Symposium. Vinkeloord, The Netherlands. October 6-10, 1997. p.77-82.	U.S.A
	Etude de la dispersion atmospherique de composes volatils odorants: solutions proposees (Atmospheric dispersion of odorus volatil compounds: proposed solutions)	Guillot, J.M. (1), H. De Melo Lisboa (2), J.L. Fanlo (2) and P. Le Cloirec (3)	1997	Proceedings of the 4th International Conference on Characterization and Control of Emissions of Odors and VOCs. October 20 to 22 1997. Montreal, Qc, Canada. p. 159-166	Canada, QC
	European Interlaboratory Comparaison of Olfactometry - Overall results and implication	Harreveld, A.Ph. van (1) and P. Heeres (2)	1997	Proceedings of the 4th International Conference on Characterization and Control of Emissions of Odors and VOCs. October 20 to 22 1997. Montreal, Qc, Canada. p. 359-374	Canada, QC
	European Interlaboratory Comparaison Olfactometry - Experiences and Results of a Participating Laboratory	Both, R.	1997	Proceedings of the 4th International Conference on Characterization and Control of Emissions of Odors and VOCs. October 20 to 22 1997. Montreal, Qc, Canada. p. 345-358	Canada, QC
	Evaluation of a Standard Sampling Method for Determination of Odour Emission from Animal Housing Systems and Calibration of the Dutch Pig Odour Unit into Standardized Odour Units	Ogink, N.W.M. and J.V. Klarenbeek	1997	Ammonia and Odour Control from Animal Production Facilities. Proceedings of the International Symposium. Vinkeloord, The Netherlands. October 6-10, 1997. p.231-238.	The Netherlands
	Evaluation of a Wind Powered Aerator to Control Odours from a Liquid Manure Storage	Toombs, M.R.	1997	Final Report. May 20, 1997. Ontario Ministry of Agriculture, Food and Rural Affairs. 14p.	Canada
	Evaluation of Commercial Products for Odor Control and Solids Reduction of Liquid Swine Manure	Warburton, D.J.(1), J.N. Scarborough, D.L. Day, A.J. Muehling, S.E. Curtis and A.H. Jensen (2)	1981	Livestock Waste: a Renewable Resource. Proceedings of an International Symposium. American Society of Agricultural Engineering. 306-313	United States
	Experiences with the Use of Biofilters to Remove Odours from Piggeries and Hen Houses	Zeisig, H.D. and T.U. Munchen	1988	Volatile Emissions from Livestock Farming and Sewage Operation. Edited by V.C. Nielsen, J.H. Voorburg and P. L'Hermite. p.209-216	
	Farmer's Option to Optimize Nutrient Efficiency and to Reduce Odour and Ammonia Emissions from Landspreading of Slurries and Manures	Nielsen, C.V. (1) and G. Steffens (2)	1994	Animal Waste Management. REUR Technical Series 34. FAO, Rome. 1994. p. 117-127.	U.K. and Germany

Environmental Issues Resource Centre
Odour Management

Reference No.	Title	Author(s)	Year	Reference	Country
	Farmer's Options to Reduce Odour and Ammonia Emissions from Animal Buildings and Storage	Voorburg, J.H.	1994	Animal Waste Management. REUR Technical Series 34. FAO, Rome. 1994. p. 5-17.	The Netherlands
	Floating Permeable Covers to Control Odor from Lagoons and Manure Storages	Miner, J.R., (1) and K.W. Suh (2)	1997	Ammonia and Odour Control from Animal Production Facilities. Proceedings of the International Symposium. Vinkeloord, The Netherlands. October 6-10, 1997. p.435-440	U.S.A.
	General considerations for odor impact study	Page, T., C. Guy, and S. Vigneron.	1997	Proceedings of the 4th International Conference on Characterization and Control of Emissions of Odors and VOCs. October 20 to 22 1997. Montreal, Qc, Canada. p. 167-181	Canada, QC
	Guideline to Assess the Protection Distance to Avoid Annoyance by Odour Sensation Caused by Livestock Husbandry.	Schauberger, G. (1) and M. Piringer (2)	1997b	Livestock Environment V. Volume 1. Proceedings of the Fifth International Symposium. Edited by Robert W. Bottcher, Steven J. Hoff. Published by the American Society of Agricultural Engineering. St. Joseph, Michigan. 49085-9659. p. 171-178	Austria
	Harmful Gas and Odor Emissions under Use of Feed and Slurry Additives	Hornig, G., W. Berg and M. Turk	1997	Livestock Environment V. Volume 1. Proceedings of the Fifth International Symposium. Edited by Robert W. Bottcher, Steven J. Hoff. Published by the American Society of Agricultural Engineering. St. Joseph, Michigan. 49085-9659. p.78-85	Germany
	Identification and Measurement of Volatile Compounds Within a Swine Building and Measurement of Ammonia Evolution Rates From Manure-Covered Surfaces	Miner, J.R. (1), M. D. Kelley and A.W. Anderson (2)	1975	Managing Livestock Wastes. ASEA Proc-275. p. 351-353	United States
	Livestock Odor Measurement using a Venturi Olfactometer and Odor Sampling using Cloth Swatches	Nicolai, R.E. (1), L.D. Jacobson (1), D.R. Schmidt (1) and C. McGinley (2)	1997a	Ammonia and Odour Control from Animal Production Facilities. Proceedings of the International Symposium. Vinkeloord, The Netherlands. October 6-10, 1997. p.193-196.	U.S.A
	Malodour Abatement by Different Covering Materials	Bundy, D.S., X. Li, J. Zhu and S.F. Hoff	1997a	Ammonia and Odour Control from Animal Production Facilities. Proceedings of the International Symposium. Vinkeloord, The Netherlands. October 6-10, 1997. p.413-420	U.S.A.
	Managing Odors from Swine, Part 2 and Part 3	Nicolai, R.	1995	Electronic documents : gaia.ageng.umn.edu/extens/ennotes/enwin95/odors.html, 2 pages gaia.ageng.umn.edu/extens/ennotes/enspr95/odor2.html, 1 page and gaia.ageng.umn.edu/extens/ennotes/ensum95/odor3.html, 1 page	United States

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Reference No.	Title	Author(s)	Year	Reference	Country
	Minimizing Emissions of Pig Husbandry Using Low Cost Biofilter and Bioactive Deep Litter	Meszaros, G.	1994	Animal Waste Management. REUR Technical Series 34. FAO, Rome. 1994. p. 65-69.	Hungary
	Modeling Odor Intensity for Swine Units	Bundy, D.S., Y.C. Chen, S.J. Hoff and J. Zhu	1997b	Ammonia and Odour Control from Animal Production Facilities. Proceedings of the International Symposium. Vinkeloord, The Netherlands. October 6-10, 1997. p.83-91.	U.S.A
	Odor and H2S Levels from Minnesota Pig Manure Storage Units.	Jacobson, L.D.	1997	In: Environmental Issues in Pork Production. The Allen D. Leman Swine Conference. September 20, 1997. Minnesota Extension Service. University of Minnesota. p. 44-55	U.S.A.
	Odor and Odor Policy Criteria	Schmidt, D. and L.D. Jacobson	1995	AEU-11. Minnesota Extension Service. Depart. of Biosystems and Agric. Engineering. Univ. of Minnesota. Electronic document : www.bae.umn.edu/extens/aeu/aeu11.html. 6 pages	United States
	Odor Control at a Large-Scale Swine Production Facility	Sidhu, K.S.(1), P.O. Warner (2) and L. Chadzynski (3)	1997	Ammonia and Odour Control from Animal Production Facilities. Proceedings of the International Symposium. Vinkeloord, The Netherlands. October 6-10, 1997. p.561-565	U.S.A.
	Odor Control in Swine Houses by the Use of Natural Zeolites: First Approach to the Problem	Airoldi, G. (1), P. Balsari (1) and R. Chiabrando (2)	1993	Livestock Environment IV. Fourth International Symposium. Coventry, England. 6-9 July 1993. p. 701-708.	Italy
	Odor Control Technologies	Bundy, D.S.	1997	In: Environmental Issues in Pork Production. The Allen D. Leman Swine Conference. September 20, 1997. Minnesota Extension Service. University of Minnesota. p. 59-65	U.S.A.
	Odor Measurements from Manure Storages on Minnesota Pig Farms	Jacobson, L.D., C. Radman, D. Schmidt and R. Nicolai	1997a	Livestock Environment V. Volume 1. Proceedings of the Fifth International Symposium. Edited by Robert W. Bottcher, Steven J. Hoff. Published by the American Society of Agricultural Engineering. St. Joseph, Michigan. 49085-9659. p. 93-100	U.S.A
	Odor Removal Using Biomass Filters	Hoff, S.J., L. Dong, X.W. Li, D.S. Bubdy, J.D. Harmon and H. Xin	1997b	Livestock Environment V. Volume 1. Proceedings of the Fifth International Symposium. Edited by Robert W. Bottcher, Steven J. Hoff. Published by the American Society of Agricultural Engineering. St. Joseph, Michigan. 49085-9659. p. 101-108	U.S.A
	Odour Control is Possible	Barrington, S.	1996	The Swine Industry at the Forefront of Environmental Issues. Proceedings of the Symposium. Saint-Hyacinthe, Quebec.	Canada

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Reference No.	Title	Author(s)	Year	Reference	Country
				September 1996. Faculty of Agricultural and Environmental Sciences. Macdonald Campus, McGill University. p.67-75	
	Odour Emission from Pig Houses with Low Ammonia Emission	Verdoes, N. (1) and N.W.M. Ogink (2)	1997	Ammonia and Odour Control from Animal Production Facilities. Proceedings of the International Symposium. Vinkeloord, The Netherlands. October 6-10, 1997. p.317-325.	The Netherlands
	Odours from Landspreading Livestock Wastes	Pain, B.F.	1994	Animal Waste Management. REUR Technical Series 34. FAO, Rome. 1994. p. 151-155.	U.K.
	Quality Assurance in Olfactometry	Berglund, B., U. Berglund (1) and T. Lindvall (2).	1988a	Volatile Emissions from Livestock Farming and Sewage Operation. Edited by V.C. Nielsen, J.H. Voorburg and P. L'Hermite. p.12-25	Sweden
	Rapport synthese - Inventaire et etude comparative des technologies de desodorisation et autres methodes et pratiques d'attenuation des odeurs de lisier	CRIQ, Universite Laval, Les Consultants BPR	1994	Dossier CRIQ no: 640-PE03364, Rapport Technique no: RDQ-94-040. Prepare pour le Ministere de l'Environnement e de la Faune. MEF. Quebec.	Quebec, CA
	Reducing Odour and Noise Conflicts Between Rural Neighbours	Fraser, H.W.	1997	OMAFRA - Housing & Environment Factsheet. Agdex 711/538. Order 92-126. Last revised : 09/97. Also electronic document: www.gov.on.ca/OMAFRA/english/livestock/swine/facts/92-126.htm	Canada
	Reduction of ammonia and odour emissions by bioscrubbers	Lais, S., E. Hartung and T. Jungbluth	1997	Ammonia and Odour Control from Animal Production Facilities. Proceedings of the International Symposium. Vinkeloord, The Netherlands. October 6-10, 1997. p.533-536	Germany
	Reduction of Ammonia, Compared with Odour Concentration on Pig and Poultry Farms	Amon, M.	1994	Animal Waste Management. REUR Technical Series 34. FAO, Rome. 1994. p. 51-58.	Slovenia
	Separation Distances for Swine Odor Control in Relation to Manure Nutrient Balances	Sweeten, J.M.	1997	Ammonia and Odour Control from Animal Production Facilities. Proceedings of the International Symposium. Vinkeloord, The Netherlands. October 6-10, 1997. p.659-665	U.S.A.
	Sludge and Slurry Disposal Techniques and Environmental Problems - A Review	Berglund, S. (1) and J.E. Hall (2)	1988b	Volatile Emissions from Livestock Farming and Sewage Operation. Edited by V.C. Nielsen, J.H. Voorburg and P. L'Hermite. p.60-72	Sweden and UK
	Surveying odor nuisance of a plant: purpose and practical guidelines. Case studies of sewage treatment plants.	De heyder, B. and A.S. Vandendriessche	1997	Proceedings of the 4th International Conference on Characterization and Control of Emissions of Odors and VOCs. October 20 to 22 1997. Montreal, Qc, Canada. p. 644-653	Canada, QC
	Swine Manure Odor Control Using Pit Additives - A Review	Zhu, J., D.S. Bundy, X. Li and N. Rashid	1997	Livestock Environment V. Volume 1. Proceedings of the Fifth International Symposium. Edited by Robert W. Bottcher,	U.S.A

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Reference No.	Title	Author(s)	Year	Reference	Country
				Steven J. Hoff. Published by the American Society of Agricultural Engineering. St. Joseph, Michigan. 49085-9659. p. 295-302	
	The Potential of Thermophillic Anaerobic Fermentation for Biological Methane Production and Odor Control Using Swine Manure as a Substrate	Williams, C.M.	1995	1995 Annual Report, Department of Animald Science, College of Agriculture and Life Sciences, North Carolina State University. Electronic document: www2.ncsu.edu/ncs...ep95/swine/swin9514.html	United States
	Thermochemical Conversion of Livestock Manure to Produce Fuel and Reduce Odor: A Feasibility Study.	Zhang, Y., B.J. He, T.L. Funk, G.L. Riskowski, R.I. Mackie, L.L. Christianson and M. Tumbleson	1997	Ammonia and Odour Control from Animal Production Facilities. Proceedings of the International Symposium. Vinkeloord, The Netherlands. October 6-10, 1997. p.429-434	U.S.A.
	Traitement de melanges gazeux odorants (NH3 et H2S) par la biofiltration sur boues granulees. (NH3 and H2S odours treatment by granular sludge biofilter)	Turgeon, N. (1), J.-L. Fanlo (2), P. Lessard (3), G. Buelna(1) and C. Gracian(2).	1997	Proceedings of the 4th International Conference on Characterization and Control of Emissions of Odors and VOCs. October 20 to 22 1997. Montreal, Qc, Canada. p. 222-237	Canada, QC
	Utilizing Ammonia Concentration as an Odor Threshold Indicator for Swine Facilities	Liu, Q., D.S. Bundy and S.J. Hoff	1993	Livestock Environment IV. Fourth International Symposium. Coventry, England. 6-9 July 1993. p. 678-685.	U.S.A
	When does Hog Odour Stink?	Thu, K.M.	1996	The Swine Industry at the Forefront of Environmental Issues. Proceedings of the Symposium. Saint-Hyacinthe, Quebec. September 1996. Faculty of Agricultural and Environmental Sciences. Macdonald Campus, McGill University. p.59-65	U.S.A.
ILES II	First Trials of Swine manure Odor Control with Depth Aeration and "Oligolyse"	Chiumenti, R., L. Donantoni, and S. Guercini	1987	Seminar of the 2nd Technical Section of the C.I.G.R. on: Latest Developments in Livestock Housing. Urbana-Champaign, Illinois. June 1987. p. 23-33	Italy
Inst. & Cent. 1a	Sensing odours - the electronic nose	SRI, Silsoe Research Institute	1995b	Annual Report 1994-1995. Silsoe Research Institute, Wrest Park, Silsoe, Bedford, MK45 4HS. pp. 40-41	England
Inst. & Cent. 1b	Waste engineering	SRI, Silsoe Research Institute	1995a	Annual Report 1994-1995. Silsoe Research Institute, Wrest Park, Silsoe, Bedford, MK45 4HS. pp. 36-37	England
OD 00-01	Odor Carrying Characteristics of Dust from Swine Facilities	Wang, X., P.G. Stroot, Y. Zhang and G.L. Riskowski	1998	Paper 984068. 1998 ASAE Annual International Meeting. July 12-14, 1998. ASAE, 2950, Niles Road, St.Joseph, MI 49085-9659. 11p.	United States
OD 00-02	Odor Emissions from Swine Nursery Buildings	Lim, T.T., A.J, Heber and J.Q. Ni	1999	Paper 994147 1999 ASAE Annual International Meeting. July 18-21,1999. ASAE, 2950, Niles Road, St.Joseph, MI 49085-9659. 12p.	United States
OD 00-03	Odor and Gas Reduction from Sprinkling	Jacobson, L.D and L.J.	1998	Paper 984125. 1998 ASAE Annual International	United States

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Reference No.	Title	Author(s)	Year	Reference	Country
	Soybean Oil in Pig Nursery	Johnston		Meeting. July 12-16, 1998. ASAE, 2950, Niles Road, St.Joseph, MI 49085-9659. 9p.	
OD 00-04	Effects of Organic Cover Biofilters on Odors from Liquid Manure Storage	Zhang, Z, T.L. Richard and D.S. Baine	1999	Paper 994087 1999 ASAE Annual International Meeting. July 18-21,1999. ASAE, 2950, Niles Road, St.Joseph, MI 49085-9659. 11p.	United States
OD 00-05	Evaluating the Use of Straw and Other Floating Materials to Control Odor Gases from Pig Manure Storage Units	Jacobson, L.D., D.R. Schmidt, R.E. Nicolai and C.J. Clanton	1999	Paper 994134, 1999 ASAE Annual International Meeting. July 18-22, 1999. ASAE, 2950, Niles Road, St.Joseph, MI 49085-9659. 5p.	United States
OD 00-06	A Better Understanding of Odour	Manitoba Livestock Manure Management Initiative	1999	Initiative Newsletter. Winter 1999. Volume 2, Issue 2. P. 1	Canada
OD 00-07	Eating Odours with Biofiltration	Manitoba Livestock Manure Management Initiative	1999	Initiative Newslatter. Winter 1999. Volume 2, Issue 2. P. 2	Canada
OD 00-08	A Sense of Swatch	Manitoba Livestock Manure Management Initiative Inc.	1999	Initiative Newslatter. Winter 1999. Volume 2, Issue 2. P. 2	Canada
OD 00-09	The Determination of Aereal Extent of Odour Plumes from Large Hog Facilities in Manitoba	Adams, Kenneth	1999	Personal Contact, Reid Crowther & Partners Ltd.	Canada
OD 00-10	Removal of Malodorous Compounds from Liquid Swine Manure by Subsurface Constructed Wetlands in a Greenhouse	Wood, S.L. and E.F. Wheeler	1999	Paper 994029, 1999 ASAE Annual International Meeting. July 18-22, 1999. ASAE, 2950, Niles Road, St.Joseph, MI 49085-9659. 13p.	United States
OD 00-11	Swine Manure Control by the TOAST Aerobic System	Goodrich, P.R. and J.J. Petering	1999	Paper 994057. 1999 ASAE Annual International Meeting. July 19-21, 1999. ASAE, 2950, Niles Road, St.Joseph, MI 49085-9659. 9p.	United States
OD 99-01	Solutions to Reduce Ammonia Levels in Swine Facilities	Meyer, Daniel J.	1985	Proceedings from the fifth International Symposium on Agricultural Wastes, December 16-17, 1985	United States
OD 99-02	The Potential of Thermophillic Anaerobic Fermentation for Biological Methane Production and Odor Control Using Swine Manure as a Substrate	Williams, C.M.(Mike)	1995	1995 Annual Report, Department of Animal Science. College of Agriculture and Life Sciences, North Carolina State University	United States
OD 99-03	Livestock Odor Control Additives: Effectiveness and Laboratory-scale Protocol For Evaluation	Williams, C.M. (Mike)	1995	1995 Annual Report, Department of Animal Science, College of Agriculture and Life Sciences, North Carolina State University	United States
OD 99-04	Managing Odors from Swine Waste AEU-8	Nicolai, Richard E.	1996	Department of Biosystems and Agricultural Engineering, University of Minnesota Extension Divison	United States
OD 99-05	Manure Application: Odor and Related Nuisances	Comfort, Steve	1997	University of Nebraska-Lincoln, Department of Agronomy, Volume 3, No 6	United States
OD 99-06	Control of Gaseous Emissions from Livestock Buildings and Manure Stores	Hartung, J., V.R. Phillips	1993	Journal of Agricultural Engineering Resources. 1993, 57, 173-189	UK
OD 99-07	An Insect-based Detector of Bovine	Raman, D. Raj, and Reid R.	1997	Proceedings from the 1997 Annual International	United States

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Reference No.	Title	Author(s)	Year	Reference	Country
	Manure Odors	Gerhardt		Meeting, Paper No. 975025, ASAE. 2950 Niles Rd., St Joseph, MI 49085-9659 USA	
OD 99-08	An On-Farm Swine Waste Treatment System for Odor Control, Byproduct Recovery and Treated Wastewater Reuse in Hawaii	Yang, P.Y., C. Gan, D.G. Paquin and T. Liang	1997	Proceedings from the 1997 Annual International Meeting, Paper No. 975025, ASAE. 2950 Niles Rd., St Joseph, MI 49085-9659 USA	United States
OD 99-09	A Study on the Air Flow and Odor Emission Rate from a Simplified Open Manure Storage Tank	Liu, Q., D.S. Bundy and S.J. Hoff	1995	Transactions of American Society of Agricultural Engineers. Vol 38(6): 1881-1886	United States
OD 99-10	Relationship Between Concentration and Intensity of Odours for Pig Slurry and Broiler Houses	Misselbrook, T.H., C.R. Clarkson and B.F. Pain	1993	Journal of Agricultural Engineering. 1992, 55, 163-169	UK
OD 99-11	Manure Odor Reduction from Pit Additives	Lorimor, Jeff	1996	ISU Extension Publication / Department of Agricultural & Biosystems Engineering, Iowa State University	United States
OD 99-13	Evaluating On-Farm Manure Storage Covers for Odor Control	Jacobson, Larry, Charles Radman, Charles Clanton, Kevin Janni, Richard Nicolai and David Schmidt	1997	1996 Annual Report - Research, University of Minnesota, Department of Biosystems and Agricultural Engineering	United States
OD 99-14	Evaluation of Experimental Swine Waste Storage Covers for Odor Control	Clanton, C., Kevin Janni, Larry Jacobson, Philip Goodrich, Roger Ruan, David Schmidt and Richard Nicolai	1997	1996 Annual Report - Research, University of Minnesota, Department of Biosystems and Agricultural Engineering	United States
OD 99-22	Reduction of Odorous Compounds in Fresh Pig Slurry by Dietary Control of Crude Protein	Hobbs, P.J., B.F. Pain, R.M. Kay, and P.A. Lee	1996	Journal of Food, Science and Agriculture. Vol. 71:4, p.508-514. 1996	UK
OD98-01	Odour and Ammonia Emission Following the Application of Pig or Cattle Slurry to Land	Pain, B.F., Y.J. Rees and D.R. Lockyer	1988	Volatile Emissions from Livestock Farming and Sewage Operation. Edited by V.C. Nielsen, J.H. Voorburg and P. L'Hermite. p.2-11	U.K.
ODO 1	Olfaktometrie Geruchsschwellenbestimmung - Olfactometry Odour Threshold Determination - Fundamentals	VDI, Verein Deutscher Ingenieure	1986a	VDI 3881 Part 1. 28 p. VDI - Kommission Reinhaltung der Luft.	Germany
ODO 10	Zeolite as feed additive to control swine manure odours and to improve animal growth performance	Barrington, S. and K. El Moueddeb	1995	Paper 95-510. Presentation to the Canadian Society of Agricultural Engineering at the Agricultural Institute of Canada Annual Conference. July 9 - 12 1995. Ottawa, Ontario. 15p.	Canada
ODO 11	A Review of the Control of Odour Nuisance from Livestock Buildings: Part 1, Influence of the Techniques for Managing	O'Neill, D. H. and V. R. Phillips	1991	Journal of Agricultural Engineering Resource (1991) 50, 1-10.	

Environmental Issues Resource Centre
Odour Management

Reference No.	Title	Author(s)	Year	Reference	Country
	Waste within the Building.	Leake, L.L.	1996a	Farm Industry News. January 1996. p 112-117.	U.S.A.
ODO 12	The drive to stifle odor	Al-Kanani, T.(1), E. Akochi (2), A.F. Mackenzie (3), I. Alli (2), and S. Barrington(4).	1992	Journal of Environmental Quality, 21: 704-708 (1992).	Canada
ODO 13	Waste Management - Odor Control in Liquid Hog Manure by Added Amendments and Aeration	Liu, Q. (1), D.S. Bubdy (2) and S.J. Hoff(2)	1995	Transactions of the ASAE. Vol. 38(6):1881-1886. American Society of Agricultural Engineering.	
ODO 14	A Study on the Air Flow and Odor Emission Rate from a Simplified Open Manure Storage Tank	Hobbs, P.J., B.F. Pain (1), R.M. Kay and P.A. Lee (2)	1996	Journal of the Science of Food and Agriculture. 1996. v. 71(4) : 508-514.	U.K.
ODO 15	Reduction of Odorous Compounds in Fresh Pig Slurry by Dietary Control of Crude Protein	Hobbs P.J., T.H. Misselbrook and B.F. Pain	1995	Journal of Agricultural Engineering Research. 1995, 60: 2, 137-144	U.K.
ODO 16	Assessment of odours from livestock wastes by a photoionization detector, an electronic nose, olfactometry and gas chromatography-mass spectrometry.	Burton, C.H. and R.W. Sneath	1995	Journal of Agricultural Engineering Research. 1995, 60: 4, 271-279	U.K.
ODO 17	Continuous farm scale aeration plant for reducing offensive odours from piggery slurry: control and optimization of the process.	Amon, M., M. Dobeic, T.H. Misselbrook, B.F. Pain, V.R. Phillips and R.W. Sneath	1995	Bioresource Technology (United Kingdom), 1995. v. 51 (2/3), p. 163-169	Slovenia, UK
ODO 18	A farm scale study on the use of De-Odorase for reducing odour and ammonia emissions from intensive fattening piggeries.	Smith, R.J.	1993	Journal of Agricultural Engineering Research. 1993, 54: 187-200	Australia
ODO 19	Dispersion of Odours From Ground Level Agricultural Sources	VDI, Verein Deutscher Ingenieure	1987	VDI 3881 Part 2. 10 p. VDI - Kommission Reinhaltung der Luft.	Germany
ODO 2	Olfaktometrie Geruchsschwellenbestimmung - Olfactometry Odour Threshold Determination - Sampling	O'Neill, D.H. (1), I.W. Stewart (2) and V.R. Phillips (1)	1992	Journal of Agricultural Engineering Research. 51, 157-165.	U.K.
ODO 20	A Review of the Control of Odour Nuisance from Livestock Buildings: Part 2, The Costs of Odour Abatement Systems as Predicted from Ventilation Requirements	Meyer, D.J. (1) and J.C. Converse(2)	1982	Transaction of ASAE. 25: 1691-1695, 1700.	U.S.A
ODO 21	Controlling Swine Manure Odors Using Artificial Floating Scums	Schiffman, S.S., E.A. Sattely Miller, M.S. Suggs and B.G. Graham	1995	Brain Research Bulletin. Vol 37, No. 4, pp. 369-375.	U.S.A.
ODO 22	The Effect of Environmental Odors Emanating from Commercial Swine Operations on the Mood of Nearby Residents	Pain, B.F., V.R. Phillips, J.F.M. Huijsmans and J.V.	1991	Rapport 91-9, December 1991, prijs f 25, -. IMAG-DLO, IGER and Silsoe Institute. Dienst	U.K. and The Netherlands
ODO 23	Anglo-Dutch experiments on odour and ammonia emissions following the				

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Reference No.	Title	Author(s)	Year	Reference	Country
	spreading of piggery wastes on arable land.	Klarenbeek		Landbouwkundig Onderzoek. Instituut voor Mechanisatie, Arbeid en Gebouwen. 28 pp.	
ODO 24	Controlling Odors from Livestock Production Facilities: State-Of-The-Art	Miner, J.R.	1981a	Livestock Waste: a Renewable Resource. Proceedings of an International Symposium. American Society of Agricultural Engineering. 297-301	U.S.A.
ODO 25	Controlling Odors from Livestock Production Facilities	Miner, J.R.	1981b	Research Results in Manure, Digestion, Runoff, Refeeding, odours. North Central Regional Research Publication No. 284. 30-35	U.S.A.
ODO 26	Management of Odors Associated with Livestock Production	Miner, J.R.	1975	Managing Livestock Wastes. ASAE PROC-27S	U.S.A.
ODO 27	Biological Removal of VFA from Animal Wastes (Volatile Fatty Acids)	Tanaka, H., K. Kuroda, and M. Yanaga	1992	Animal Science and Technology. (Jpn.). 63 (1): 54-59	Japan
ODO 28	The Use of Dried Bacteria Cultures and Enzymes to Control Odor and Liquefy Organic Waste Found in Hog, Dairy and Poultry Producing Units as Well as Lagoons	Bergdoll, J.F.	1975	Managing Livestock Wastes. ASAE Proc-27S: 372-373	U.S.A.
ODO 29	Methods for Evaluating Odor from Swine Manure	Riskowski, G.L., A.C. Chang, M.P. Steinberg and D.L. Day	1991	Applied Engineering in Agriculture. 7 (2): 248-253	U.S.A.
ODO 3	Olfaktometrie Geruchsschwellenbestimmung - Olfactometry Odour Threshold Determination - Olfactometers with gas jet dilution	VDI, Verein Deutscher Ingenieure	1986b	VDI 3881 Part 3. 10 p. VDI - Kommission Reinhaltung der Luft.	Germany
ODO 30	Odor Control of Liquid Dairy and Swine Manure Using Chemical and Biological Treatments	Cole, C.A., H.D. Bartlett, D.H. Buckner and D.E. Younkin.	1975	Managing Livestock Wastes. ASAE Proc-27S: 374-377	U.S.A.
ODO 31	Evaluation of Commercial Manure Additives to Control Odors from Swine Barns	Nicolai, R.E.(1), J. Johnson (2) and R.L. Mensch (3)	1997b	Paper 974041. 1997 ASAE Annual International Meeting. August 10-14, 1997. ASAE, 2950, Niles Road, St.Joseph, MI 49085-9659.	U.S.A.
ODO 32	Odor Control Additives: Protocol for Evaluation	Williams, C.M.	1995	Proceeding Wastes Symposium. University of Florida. March 21-22, 1995. p. 36-43	U.S.A.
ODO 33	Olfactometry Measurement of Animal Manure Odor	Sobel, A.T.	1972	Transactions of the ASAE. 1972 p. 696-699 - 703	U.S.A
ODO 34	Examining the performance of additives in reducing the odor and ammonia emissions from slurry with a standard test procedure.	Buscher, W. (1), E. Hartung (2), T. Jungbluth (2)	1997	Paper 974121. 1997 ASAE Annual International Meeting. August 10-14, 1997. ASAE, 2950, Niles Road, St.Joseph, MI 49085-9659. 7p.	Germany
ODO 35	Design, Construction, and Validation of a Pilot-Scale Biofiltration System for the Reduction of Swine Odor	Young, J.S. (1), J.J. Classen (2), R.W. Bottcher (2) and P.W. Westerman (2)	1997a	Paper 974039. 1997 ASAE Annual International Meeting. August 10-14, 1997. ASAE, 2950, Niles Road, St.Joseph, MI 49085-9659.	U.S.A

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Reference No.	Title	Author(s)	Year	Reference	Country
ODO 36	Development of a Low Cost Biofilter for Swine Production Facilities	Nicolai, R.E.and K.A. Janni	1997	Paper 974040. 1997 ASAE Annual International Meeting. August 10-14, 1997. ASAE, 2950, Niles Road, St.Joseph, MI 49085-9659. 8p.	U.S.A
ODO 37	Evaluating the Toast R Aerobic System for Odor Control	Goodrich, P.R. (1)and J.L. Petering (2)	1997	Paper 974037. 1997 ASAE Annual International Meeting. August 10-14, 1997. ASAE, 2950, Niles Road, St.Joseph, MI 49085-9659. 9p.	U.S.A
ODO 38	Development of a Dynamic Olfactometer Lab	Nicolai, R.E., C.J. Clanton, P.R.Goodrich, L.D. Jacobson, K.A. Janni, V.J. Johnson, E.Lees and D.R. Schmidt	1997c	Paper 974019. 1997 ASAE Annual International Meeting. August 10-14, 1997. ASAE, 2950, Niles Road, St.Joseph, MI 49085-9659.	U.S.A
ODO 39	Reduction of Ammonia and Odor Emissions from a Piggery with Biofilters	Hartung, E., T. Jungbluth and W. Buscher	1997	Paper 974126. 1997 ASAE Annual International Meeting. August 10-14, 1997. ASAE, 2950, Niles Road, St.Joseph, MI 49085-9659.	Germany
ODO 4	Olfaktometrie - Bestimmung der Geruchsintensitat - Olfactometry - Determination of Odour Intensity	VDI, Verein Deutscher Ingenieure	1992	VDI 3882 Part 1. 27 p. Kommission Reinhaltung der Luft im VDI und DIN.	Germany
ODO 41	Odor Emission from Traditional and Low-emitting Swine Housing Systems: Emission Levels and their Accuracy	Ogink, N.W.M., C. ter Breek and J.V. Klarenbeek	1997	Paper 974036. 1997 ASAE Annual International Meeting. August 10-14, 1997. ASAE, 2950, Niles Road, St.Joseph, MI 49085-9659. 6p.	The Netherlands
ODO 42	Fabric Swatches as an Aid in Livestock Odor Evaluations	Miner, J.R. and L.A. Licht	1981	Livestock Waste: a Renewable Resource. Proceedings of an International Symposium. American Society of Agricultural Engineering. 302-305	U.S.A.
ODO 43	Odorous Compounds from Treated Pig Manure	Yu, J.C. (1), C.E. Isaac, R.N. Coleman (2), J.J.R. Feddes (1) and B.S. West (3)	1991	Canadian Agricultural Engineering. 33(1): 131-136.	Canada
ODO 44	Final Report. "Evaluation of Commercial Manure Additives"	AURI, Agricultural Utilization Research Institute	1997	Agricultural Utilization Research Institute. Jack Johnson, P.O. Box 251, Waseca, MN 56093	U.S.A
ODO 46	Options for Managing Odor.	Swine Odor Task Force.	1995	Published by the North Carolina Agricultural Research Service, North Carolina State University. Electronic document: www.ces.ncsu.edu/whpaper/SwineOdor.html. 45 p. Consulted on 10/14/1997.	U.S.A
ODO 5	Olfaktometrie - Bestimmung der hedonichen Geruchswirkung - Olfactometry - Determination of Hedonic Odour Tone	VDI, Verein Deutscher Ingenieure	1994	VDI 3882 Part 2. 19 p. Kommission Reinhaltung der Luft im VDI und DIN.	Germany
ODO 6	Wirkung und Bewertung von Geruchen - Effects and Assessment of Odours - Determination of Annoyance Parameters	VDI, Verein Deutscher Ingenieure	1993a	VDI 3883 Part 2. 30 p. Kommission Reinhaltung der Luft im VDI und DIN.	Germany

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Reference No.	Title	Author(s)	Year	Reference	Country
	by Questioning Repeated Brief Questioning of Neighbour Panellists				
ODO 7	Bestimmung der Geruchsstoffimmission durch Begehungen - Determination of Odorants in Ambient Air by Field Inspections	VDI, Verein Deutscher Ingenieure	1993b	VDI 3940 31 p. Kommission Reinhaltung der Luft im VDI und DIN.	Germany
ODO 8	Biologische Abgas-/Abluftreinigung - Biofilter. Biological Waste Gas/Waste Air Purification - Biofilters.	VDI, Verein Deutscher Ingenieure	1991	VDI 3477, 32 p. Kommission Reinhaltung der Luft im VDI und DIN.	Germany
ODO 9	Reduction of Odorous Compounds in Pig Manure by Lowering Dietary Crude Protein	Heartland Lysine, Inc.	1997	Swine Research Report 25. Reducing Odor. Heartland Lysine, Inc. 8430W. Bryn Mawr, Suite 650, Chicago IL 60631. 4 p.	U.S.A.

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Modeling Odor Intensity for Swine Units
Bundy, D.S., Y.C. Chen, S.J. Hoff and J. Zhu
1997b
Ammonia and Odour Control from Animal Production Facilities. Proceedings of the International Symposium. Vinkeloord, The Netherlands. October 6-10, 1997. p.83-91.
U.S.A
The intensity of an odor can be perceived directly without knowing its corresponding concentration. A relationship doing the link between odor concentration and odor intensity could helpful in the analysis of early research and also in the definition of standards and regulations as odor threshold could be used with the odor intensity in defining more the odorous situation. Different mathematical models were evaluated (Weber-Fechner law model, the power law model, the Stevens model, and the Beidler model) in associated to odor threshold and odor intensity evaluations (on a 6 points scale) of a panel using olfactometry to analyze odorous samples from farrowing, finisher, gestation and nursery rooms. The results from those models and the panel evaluations showed that the widely used Weber-Fechner law model did not fit the odor intensity and threshold panel's data for swine building. Better estimations for the odour intensity were obtained with the power law and the Beidler model; this last model showing the best fit of the experimental data; it was thus chosen to represent the relationship between odour threshold and odour intensity.

As mentioned in the paper more experiments would be needed to verify the conclusion of this study. The development of such tool is important because when those kinds of tools are reliable less costly direct measurements have to be done to represent a given situation.

Dust Effects on Odour and Odour Compounds
Hoff, S.J., D.S. Bundy and X.W. Li
1997a
Ammonia and Odour Control from Animal Production Facilities. Proceedings of the International Symposium. Vinkeloord, The Netherlands. October 6-10, 1997. P.101-110.
U.S.A
The influence of dust particles on doors coming from livestock building was evaluated in laboratory using full-scale installations. The ventilation air coming from four nursery rooms ventilated separately passed through chopped cornstalks and corncobs used as substrate in four biofilters. Samples of the ventilation air before and after the biofilters treatments were taken for dust analysis (total dust concentration, the particle distribution) and odour threshold determination by olfactometry. The results obtained showed that the odour threshold could be reduced to up to 76% with particles removal of nearly 100%. These results agreed with previous work suggesting that dust particles are odour carrier as the odour compounds probably adhere to the particles. The biofilters used were effective in removing particles in excess of 10 microns.

The odour emission reduction by dust removal is very interesting. This work however doesn't give any information about the investment and operation cost of such biofilters, as booster fans have to be used to push the ventilated air through the filters. Dust removal would be even more interesting if the dust inside the building could be controlled to improve the inside conditions for swine and workers.

Developing an Olfactometer for Livestock Odor Evaluation
Li, X.W., D.S. Bundy and S.J. Hoff
1997
Ammonia and Odour Control from Animal Production Facilities. Proceedings of the International Symposium. Vinkeloord, The Netherlands. October 6-10, 1997. P.155-160.
U.S.A
As odor produced by livestock production systems became an increasing concern of the public and resulted in many complaints, the need to determined odor threshold concentration with reliable and rapid methods has also increased. As malodorous compounds from livestock production are numerous and complex to analyze, olfactometry is still the best method to scale the human sensory response to odor. A new automated triangular forced-choice olfactometer was developed according to ASTM Standard and evaluated. This olfactometer features 15 dilution levels and testing of most odor samples can completed in less then 10 minutes by 4 panellists. To obtained accurate results with olfactometry, it is important to give enough attention to panel selection and training, to selection of sampling bags, to the storage of the samples and to the calibration of the olfactometer. Testing on sampling bag showed that Tedlar bags are more reliable than PVC bags due to the lowest permeability of Tedlar and that samples in those bags can be stored to up to a week with little changes in the results. If the odor analysis are done within a few hours (less than 4) polyethylene bags, which less expensive, can be used.

The testing of the sample bags is interesting because it gives more information about the aging of the sample and help choosing the best sample bags according to the delay before sampling analysis. For the olfactometer, some descriptions are given but they are very brief.

Livestock Odor Measurement using a Venturi Olfactometer and Odor Sampling using Cloth Swatches

Environmental Issues Resource Centre

Odour Management

Nicolai, R.E. (1), L.D. Jacobson (1), D.R. Schmidt (1) and C. McGinley (2)
1997a
Ammonia and Odour Control from Animal Production Facilities. Proceedings of the International Symposium. Vinkeloord, The Netherlands. October 6-10, 1997. P.193-196.
U.S.A
C. McGinley designed a venturi olfactometer that consists in a single presentation port to the panellist supplied by a solenoid and orifice system that control the air flow from the clean air supply and from the odorous sample. Tests of this design were done at the University of Minnesota over a period of three months and the venturi olfactometer proved his reliability and repeatability for dilution of 10.5 to 5793. This design presents many advantages which are: the very short distance between the mixing of the odorous sample and the fresh air and the presentation port, the purging time is short between the change of samples, the required odorous air mix to realize the sample testing is small, less residual contamination, and less time between dilution steps. Odor sampling with cloth swatch was also tested as a mean to transport the odors to the olfactometer. Cloth swatches were suspended (at 1,5 m from the slatted floor) in a finishing building for 8 hours and a pulsed air pump set to collect the air at the same level for the same period and store it in a Tedlar bag was also installed. Olfactometry analysis was then done on the cloth swatches and the air samples to compare both techniques. The results showed that for odor levels that are very low some correlation might exist between both techniques however, for medium to high odor concentrations no correlation could not be done.

The venturi olfactometer seems to be interesting considering its advantages. It would also be interesting to verify if the results obtained with this equipment are repeatable from one venturi olfactometer to another because apparently, the tests were done on the same olfactometer. The cloth swatch technique should not be used for odor intensity testing.

Evaluation of a Standard Sampling Method for Determination of Odour Emission from Animal Housing Systems and Calibration of the Dutch Pig Odour Unit into Standardised Odour Units
Ogink, N.W.M. and J.V. Klarenbeek
1997
Ammonia and Odour Control from Animal Production Facilities. Proceedings of the International Symposium. Vinkeloord, The Netherlands. October 6-10, 1997. P.231-238.
The Netherlands
In the Netherlands an odour research program was started to study odour from conventional housing systems and also new low ammonia systems using a new official odour measurement protocol. These measurements should give the basis for the integration of the new systems in the odour regulatory system. The results of the first year program are presented and emphasis is made on the new protocol and calibration of the Pig odour unit evaluation. The protocol evaluation was done for two conventional pig-housing systems: fattening pigs (FP) and sows in individual stalls (SP) both on partly slatted floors and for each system four farms were chosen. The experimental design and analysis was done to obtain the variation between and within the farms and also the variation coming from the olfactometric measurements for both systems. The variations between-farm were 22% (for FP) and 2% (for SP) mean percentage deviations, the variation within-farm was 34% (FP) and 19% (SP) and the variation between duplicate samples were 16% (FP) and 23% (SP). For the FP system the odour emission geometric mean was 22.6 odour units/s per animal place for a ventilation rate of 33.3 m3/h per animal. The protocol used prescribes ten sampling days for the sampling of single farm and considering the estimated variation sources, the accuracy levels obtained are of 24.5% for FP and 8.1% for SP. Higher accuracy, 9.5% for FP and 6.7% for SP could be obtained with the same number of odour samples by taking one sample on 20 different farms. On conclusion, all variation sources should consider for each animal category before the protocol design of housing systems evaluation. The resulting sample strategies could then be different between animal categories.

When odor is regulated and controlled, standard protocols should be establish for odor determination of specific housing systems. Those protocols may be quite complex to establish because all variation sources have to be considered for all animal categories. For example, the growing stage in a fattening building will have an impact on those variations (beginning of the period vs. end of the period for all-in all-out).

Control of Odours by Dietary Manipulation
Hobbs, P.J. (1), B.F. Pain (1), R.M. Kay (2) and P.A. Lee (2)
1997
Ammonia and Odour Control from Animal Production Facilities. Proceedings of the International Symposium. Vinkeloord, The Netherlands. October 6-10, 1997. P.267-272.
U.K.
Control odour emissions by dietary manipulations involve could be an interesting odour reduction mean as the intervention on odour is done at the beginning of the waste management process and could limit the need for air treatment investments. Two experimental reduce crude protein (RCP) diets were tested against a commercial diet (CD) as feed to fattening pigs. The first RCP diet was made out of bean and peas (BP) and the other one was fishmeal and Soya based (FS), both contained barley and wheat and was supplemented synthetic amino acids to obtain an ideal ratio of essential amino acids. Gas chromatography

- mass spectrometry was used to identify and quantify the major odour components found in the headspace of fresh pig slurry. Results showed in comparison with CD results, that 9 out of 10 odorous components were reduced in the slurry produced by the pigs fed the FS ($P<0.05$) as for the BP; reduction was measured for 4 odorants ($P<0.05$). This shows that not only the crude protein content of a diet has an effect on odorants production but also the diet components affect the odour components of found in the headspace of the fresh manure. For both BP and FS, the ammonia emissions were reduced by 40% compare to CD and other parameters such as pH, dry matter content, total and organic nitrogen were also reduced.

The reduction of odorous compounds by the reduction of the crude protein in the diet is very interesting because this reduction is done directly as the manure is produced. However a reduction of certain components may not necessarily mean odour reduction as the authors present it. Odour from slurry comes from many different components and conclusions could not be drawn on measured reductions of 10 compounds. Furthermore the hedonic odor tone (pleasant or unpleasant) has also to be verified to conclude on an improvement in the odor.

Odour Emission from Pig Houses with Low Ammonia Emission
Verdoes, N. (1) and N.W.M. Ogink (2)
1997
Ammonia and Odour Control from Animal Production Facilities. Proceedings of the International Symposium. Vinkeloord, The Netherlands. October 6-10, 1997. P.317-325.
The Netherlands
Presently in the Netherlands for each category of pigs, low cost Green Label systems are available. Low ammonia emission (Green Label) and most of the time low odour emission are criteria for permitting the building of new livestock facilities. This paper presents research done to determine the odour emission levels of 5 systems for different categories of pig that are under The Dutch Green Label standard for ammonia emission. Those systems are variations of traditional systems with differences in the units' layout and in some case changes also in the feeding strategies. For each system 5 odour samples were taken in both summer and winter. The measurements and analysis were done accordingly to the newly developed protocol for animal housings odour emissions. Results showed that consistently the odour emission were higher in the summer than in the winter. The odour emissions are expressed in odour units/s per pig place and the geometric mean of each system are as follow: 10.92 for dry sows in rooms with small manure channels, 35.27 for farrowing sows in rooms with a water and a manure channel, 4.95 for weaned piglets in an optimized pen design, 14.21 for fatteners in an optimized pen design and fed with acid salts in the feed and 10.10 for fatteners in an optimized pen design and fed with multiphase feeding these two systems represent an odour emission reduction of 37% and 55% ($P<0.025$) respectively compare to fatteners' traditional housing. Results' analysis show that more research is needed to identify the factors that affect odour emission and the relations between odour concentration and ammonia concentration. The odour emission ratios between categories found in this experiment differ from the ones on the present regulatory system.

Ways of reducing odour emissions were tested with a rigorous protocol and actual emissions were tested to complete the Green Label regulation regarding odour emission. All odour emission mechanisms are far from well understood and as mentioned, research is need.

Comparison of Hydrogen Sulfide and Odor Emissions from Animal Manure Storages
Jacobson, L.D., C.J. Clantont, D.R. Schmid, C. Radman, R.E. Nicolai and K.A. Janni
1997b
Ammonia and Odour Control from Animal Production Facilities. Proceedings of the International Symposium. Vinkeloord, The Netherlands. October 6-10, 1997. P.405-412.
U.S.A.
Air samples were taken from approximately 60 different livestock manure storage units (pigs, dairy, beef and poultry) for hydrogen sulfide (H_2S) concentrations and odor dilution thresholds or odor level. Odor thresholds determination was realized with an olfactometer and H_2S concentrations were measured using either colormetric indicator tubes (concentration between 20 to 120 ppm) or a Jerome TM meter (concentrations lower than 20 ppm). Over 80 measurements were taken during the initial phases of the 2-year projects (fall 1996); the odor threshold values varied from 17 to 1200 odor units and the H_2S concentrations ranged from 6 ppb (parts / billion) to 118 ppm (parts / million). No correlation was obtained between odor threshold and H_2S concentration.

H_2S as ammonia concentrations (presented in other publications) cannot be considered as indicators of odor thresholds or odo levels.

Malodour Abatement by Different Covering Materials
Bundy, D.S., X. Li, J. Zhu and S.F. Hoff
1997a
Ammonia and Odour Control from Animal Production Facilities. Proceedings of the International Symposium. Vinkeloord, The Netherlands. October 6-10, 1997. P.413-420
U.S.A.

Environmental Issues Resource Centre

Odour Management

The capacity of controlling odor emissions of low cost organic and inorganic materials used to cover manure surface was studied in a research project. 14 steel tanks of 1.83 m diameter by 1.22 m high were buried 0.9m in the soil and the tanks were filled with manure on 0.9 m (0.32 m left on top for cover treatment). Different covering materials were applied on the manure surface: chopped straw, cornstalks, polyethylene open mesh with a liquid surface film, Leka rock, and foam generated from air bubbles and manure solids. Their odor control capacity was verified by olfactometry analysis and chemical analysis of air samples taken in the headspace of each tanks weekly for 9 weeks. The chemical analysis was done with sample detector tubes on the following identified compounds: ammonia, hydrogen sulfide, ethyl mercaptan and methyl mercaptan. Results show that straw, cornstalks, Leka rock, and surface foam can reduce odors, the reusable Leka rock being the more costly ($150 to $180 U.S. /m3). For scale applications the odor reduction rate and the cost still have to be determined to find acceptable manure covering strategies. The effect of wind on the material applied on large tanks and also the covers' longevity and integrity still have to be investigated on real scale tanks.

The behaviour of those covers was not verified for large tanks; the covers giving the more promising results should be verified for field situations. Odor reduction capacities should be determined and also the techniques for cover application and maintenance. The choice of a covering strategy for farm application could than be done.

Thermochemical Conversion of Livestock Manure to Produce Fuel and Reduce Odor: A Feasibility Study.
Zhang, Y., B.J. He, T.L. Funk, G.L. Riskowski, R.I. Mackie, L.L. Christianson and M. Tumbleson
1997
Ammonia and Odour Control from Animal Production Facilities. Proceedings of the International Symposium. Vinkeloord, The Netherlands. October 6-10, 1997. P.429-434
U.S.A.

The thermochemical conversion process (TCC) has been studied and used for coal and wood sludge application in the oil crisis of the '70 but because of the high cost of entrants and the oil costs that decreased the research was not sustained. This process is a chemical reforming reaction where organic compounds in anaerobic conditions are heated in a pressurized enclosure. The macromolecules such as cellulose are then broken into more simple molecules of 4 to 10 carbon chains such as oils and into single carbon molecules such as methane, carbon dioxide and carbon monoxide. Manure characteristics (uniformity, energy and nutrient contents, sodium and carbon monoxide acting as catalysts in the early treatment stage), its availability, and its low cost makes it a much more desirable feed stock compared to liquidated coal and wood sludge. A preliminary study was realized to verify the TCC of livestock manure. The processing of a sample of 500 g of swine manure (20% solid and 80% water) was done in a cylinder-shape reactor at pressure varying between 13.6 and 34 bars and temperatures ranging between 250 and 490 C. This test resulted in 19.1% of the raw manure being converted into low-sulphur oils and 7.2% into methane. As TCC is a closed-loop process, a better waste management and odor control are expected. Further research is needed to optimize the operation parameters and to evaluated the economic viability of such technology applied to livestock waste.

This technology could become interesting as an alternative to fossil fuel if the technology is well controlled and adapted to livestock wastes. As long as the fuel cost stay as its present level it may be difficult to justify the technical level, complexity and costs associated to TCC.

Floating Permeable Covers to Control Odor from Lagoons and Manure Storages
Miner, J.R., (1) and K.W. Suh (2)
1997
Ammonia and Odour Control from Animal Production Facilities. Proceedings of the International Symposium. Vinkeloord, The Netherlands. October 6-10, 1997. P.435-440
U.S.A.

Ten different polystyrene foam materials of thickness ranging from 1 to 3 cm were tested for their ability to reduce ammonia and odors emissions from the surface of stored liquid swine manure. The manure was stored in 0.30 m diameter and 0.365 m high pails. Ammonia concentrations were measured and odor emission was evaluated using cotton fabric swatches. All the materials evaluated reduced ammonia emissions from 45 to 90% compared to uncovered manure. Odor panellist could identify an odor intensity reduction as result to cover use. The more effective cover materials presented a sufficient gas permeability allowing the gases to pass through the foam an undergo aerobic breakdown. For less permeable covers, the gas (odor and ammonia) passed around the covers.

The cover testing was done on a very small scale, which raises questions about the validity of such results on a larger scale. The odor analysis done with the cloth swatch technique can also be questioned if we consider the results obtained by R.E. Nicolai et al., 1997 (in the same conference).

Biofiltration System for Testing the Reduction of Odor from Swine Buildings
Young, J.S., J.J. Classen, R.W. Bottcher and P.W. Westerman
1997b
Ammonia and Odour Control from Animal Production Facilities. Proceedings of the International Symposium. Vinkeloord, The Netherlands. October 6-10, 1997. P.521-528
U.S.A.
Testing was done at North Carolina State Univ. on 3 pilot-scale biofilters and the apparatus related to the operation of such biofilters built to treat odorous air coming from the swine gestation-building pit. The biofilter medium was a 3:1 mix of yard waste compost mixture and wood chips mixture. Temperatures flow rates, and a computer through out the testing measured pressure drop and the computer also measured and controlled the moisture content of the biofilter medium. This project wanted to evaluate the performance of those biofilters and ensure that this setting would be useful for future research projects on scientific experiments of swine odor reductions. The odor measurements were done using the cotton swatch absorption method and a panel analyzed the samples. Odor intensity, irritation intensity and unpleasantness were the parameters measured in five tests and the reductions from the use of biofilters compared to untreated odorous air were 61%, 58%, and 84% respectively.

This pilot scale experiment is interesting because it could lead to larger scale installations. However the odor analysis done with the cloth swatch technique can be questioned if we consider the results obtained by R.E. Nicolai et al., 1997 (in the same conference).

Reduction of ammonia and odour emissions by bioscrubbers
Lais, S., E. Hartung and T. Jungbluth
1997
Ammonia and Odour Control from Animal Production Facilities. Proceedings of the International Symposium. Vinkeloord, The Netherlands. October 6-10, 1997. P.533-536
Germany
Bioscrubbers technology has been discussed in the last few years for odour emissions reduction for animal buildings. This present project aims at the determination of ammonia and odour reduction efficiency of 3 different types of bioscrubbers (different by their dimensions) used on pig farms. The major factors influencing the performance of the bioscrubbers in reducing odours and ammonia were determined and the cost associated with biofilters was evaluated. Bioscrubbers have proven to be effective in odour reduction (reduction ranging from 61 to 89%). However they are unsuitable for ammonia emission reduction from farms, the ammonia emissions are not treated in a satisfactory way as ammonia emission can be done in a more effective and cheaper way. The costs of the bioscrubbers range from 9 U.S.$ to 17 U.S.$ per fattening pigs.

This technique is interesting for odour reduction but in a near future, as it is done in Europe, ammonia emissions will have to be controlled also. The bioscrubbers tested here are not interesting because of its expensive cost. Also as the air is washed by water and sludge flow; treatment of this effluent has also to be done. Improvements in the technology have to be done to make bioscrubbers interesting for on farm applications.

Environmental Issues Resource Centre

Odour Management

Biofilter/Wetscrubber Combinations for the Reduction of Ammonia, Odour and Dust Emissions of Pig Fattening Houses
Siemers, V. and H. Van den Weghe
1997
Ammonia and Odour Control from Animal Production Facilities. Proceedings of the International Symposium. Vinkeloord, The Netherlands. October 6-10, 1997. P.537-544
Germany
Biological waste air purification from a pig-fattening house was tested with the use of a Biofilter/wetscrubber combination (BWC). The results showed that when the biofilter material was sprayed with tap water at an intensity of more than 50 l/m2 per day an efficiency of 90% was obtained in ammonia reduction for the overall BWC. When the biofilter was sprayed with the scrubbing liquid of the wetscrubber, the efficiency decreased to 50% and if no liquid is sprayed on the filter material, the efficiency goes as low as 13%. It is clear that the spraying of biofilter is essential for ammonia emission reduction. The BWC reduced dust emissions to as much as 80%. The air quality was also measured to verify the BWC treatment for odour reduction. However conclusions could not be drawn from olfactometric analysis because strong self-odour resulted from the filter material of BWC. The total costs of for the tested BWC range between DM 20.80 and DM 22.90 / fattened animal per year (14 to 15 U.S.$). Before doing the investment in the use of BWC other management methods should be considered and optimized (for example: feeding, manure storage).

This system is not simple and is quite expensive. The air coming from the livestock building is scrubber by spraying a mix of tap water (added to compensate for the evaporation) and recycled sludge (the sprayed liquid is being pump and sprayed again) and this air goes through the biofilter that is installed on the top of the scrubbing room. The liquid and the biofilter material have to be disposed and replaced at a certain time and this doesn't seem to be considered in the costs.
1DM = 0.7942 $CAN (02/14/1998)

Odor Control at a Large-Scale Swine Production Facility
Sidhu, K.S. (1), P.O. Warner (2) and L. Chadzynski (3)
1997
Ammonia and Odour Control from Animal Production Facilities. Proceedings of the International Symposium. Vinkeloord, The Netherlands. October 6-10, 1997. P.561-565
U.S.A.
A large-scale swine production facility has been investigated to find solutions to many odor complaints done by nearby neighbours. This facility houses 50 000 animals and manure is stored in 3 football-field size lagoons. Within a half-mile radius of this setting, live neighbours that have been reporting nuisance from the odor emission of the facility and also alleged farm odor-related health problems, which included nose and throat irritation, nausea, vomiting, headaches, sleep problems and breathing difficulties. Odor measurements were taken to identify the production activities that generated most odors and gestation and nursery buildings and field-sprinkling operations were pointed out. Steps were taken to lower the odor-related releases and the following techniques were selected: centrifugal separation and drying of solid waste and soil injection of liquid waste on farm land, and erecting windbreaks by planting multiple rows of trees. The implementation of such methods and maintenance of controls help reduce the odorous emissions. The number of complaints significantly deceased following these management steps.

This investigation and the steps that followed are an interesting example of the type of intervention that could be done to find solutions to odor problems adapted to a particular facility using a system approach. The size of this facility dictated such intervention as the odor problems were probably important and due to the scale of the facility a team of specialists could investigate.

Separation Distances for Swine Odor Control in Relation to Manure Nutrient Balances
Sweeten, J.M.
1997
Ammonia and Odour Control from Animal Production Facilities. Proceedings of the International Symposium. Vinkeloord, The Netherlands. October 6-10, 1997. P.659-665
U.S.A.
Odor control from swine facilities can be achieved by providing an adequate buffer zone or separation distance from neighbours. Such separation distance could be insured if appropriate nutrient balance is done considering the facility size, the type of animal and manure and the wastewater management system. The paper presents examples, which include phosphorus and nitrogen nutrient balance consideration and the resulting minimum separation distances that would have to be insured.

This approach consider the nutrient balance in agricultural systems where the manure is used as fertilizer on the land surrounding the swine facilities considering that all the land needed is surrounding the facilities.

Assessment of the protection distance to avoid annoyance by odour sensation caused by livestock husbandry by Austrian guideline
Schauberger, G. (1) and M. Piringer (2)

1997a
Ammonia and Odour Control from Animal Production Facilities. Proceedings of the International Symposium. Vinkeloord, The Netherlands. October 6-10, 1997. P.677-684
Austria
Different guidelines have been developed and are used in some European countries to define minimum distances that should be respected to separate livestock buildings from residential areas, these distances being considered necessary for odour dilution thus limiting nuisance from livestock production activities. The Austrian guidelines are presented and are in some ways similar to existing guidelines. An odour number is calculated using the following parameters: number of farm animals, their category and their housing system, characteristics of the outlet and the exhaust air velocity, the manure management inside and outside the building and the feeding strategy. Odour dispersion is first evaluated using the wind direction mean distribution at the site and secondly by evaluating the predominant local winds the last consideration is the legal claim of protection by the surrounding residential areas. This analysis results in a final protection distance dependent on the direction to the neighbours. This paper present the Austrian guideline and discuss the differences from Switzerland, Germany and the Netherlands guidelines.

The protection distances considering fattening pigs are compared graphically in the publication (the protection distance as a function of the number of fattening pigs) and no trends can be seen of one country being consistently more restrictive than the other.

Harmful Gas and Odor Emissions under Use of Feed and Slurry Additives
Hornig, G., W. Berg and M. Turk
1997
Livestock Environment V. Volume 1. Proceedings of the Fifth International Symposium. Edited by Robert W. Bottcher, Steven J. Hoff. Published by the American Society of Agricultural Engineering. St. Joseph, Michigan. 49085-9659. P.78-85
Germany
This investigation was done on a laboratory scale with manure samples for the "oxygen information" substances (quartz or chalk powder), the manure acidification treatment (using lactic acid) and the manure algae treatment. The investigation on the Bentonite feeding additive and the manure yeast treatment were done directly in pig housing. The laughing gas mentioned in the abstract is NO2. The "oxygen information" substances highly advertised and commonly used in Germany, Austria and Switzerland is apparently "equipped with oxygen information by means of cosmic energy".
Further tests have to be done on a farm scale for the products that worked well in laboratory before recommendations could be done and the impact of manure acidification on soil and crop production has to be verified.
Odour reduction is claimed but no results are shown to confirm it.

Odor Measurements from Manure Storages on Minnesota Pig Farms
Jacobson, L.D., C. Radman, D. Schmidt and R. Nicolai
1997a
Livestock Environment V. Volume 1. Proceedings of the Fifth International Symposium. Edited by Robert W. Bottcher, Steven J. Hoff. Published by the American Society of Agricultural Engineering. St. Joseph, Michigan. 49085-9659. P. 93-100
U.S.A
Investigations on odor and hydrogen sulfide emissions have been done on 30 pig manure storage facilities in Minnesota. A wide range of odor concentration levels and hydrogen sulphide concentrations have been measured during fall weather conditions. A procedure to sample the odor directly over the manure was elaborated in order to eliminate other odor sources. Storage classification was made and the results are presented according to this classification: indoor deep pit, outdoor concrete metal structure, earthen basin and 2nd stage earthen basin. No storage system showed lower concentrations for both parameters measured. The average odor concentration measure for all storage systems was 150 odor units. H2S concentration measurements were higher for non-earthen systems than for earthen basins. The H2S concentration was distributed in two blocs with concentrations around lower than 10 ppm or higher than 50 ppm.
The methods used to realize the experiment are well presented and are follow ASTM and European Standards. No trend and no logical physical explanation can justify the large differences in odor dilution threshold and H2S concentrations obtained from the different manure storage systems. Thus not initially expected, the role that management practices may play in odor and gas emissions could probably be accounted for these large differences. As the experiment continue in 1997 more results and investigation will probably help in the determination of the factors affecting odor and gas production such as possible seasonal effects, temperature, animal diets, pumping frequencies, and general storage management.

Odor Removal Using Biomass Filters
Hoff, S.J., L. Dong, X.W. Li, D.S. Bubdy, J.D. Harmon and H. Xin
1997b
Livestock Environment V. Volume 1. Proceedings of the Fifth International Symposium. Edited by Robert W. Bottcher, Steven J. Hoff. Published by the American Society of Agricultural Engineering. St. Joseph, Michigan. 49085-9659. P. 101-108
U.S.A
In this publication, results are presented for a biomass filters made of cornstalks and corncobs as substrate. See the publication

in the "Other notes" for more complete comments. More investigation is needed to understand the periodic odor release that occurred.
The experiment was also supposed to test a compost biofilter which technology was abandoned after few weeks trial due to the very high energy cost associated with the fan requirements and the high static pressure across the filter, the chosen design proved to be inappropriate.
More work is needed to better understand the relationship between dust concentration and associated odor components and also to find better filter media that is effective in dust and odor removal but show little airflow resistance considering the important air volumes that have to be treated from ventilated livestock buildings.

Determination of the Odor Plume Boundaries from Animal Houses
Hartung E. and T. Jungbluth
1997
Livestock Environment V. Volume 1. Proceedings of the Fifth International Symposium. Edited by Robert W. Bottcher, Steven J. Hoff. Published by the American Society of Agricultural Engineering. St. Joseph, Michigan. 49085-9659. P. 163-169
Germany
The well-known methods that are used to measure the airborne pollutants cannot be used to evaluate odorants in the outdoor air. The German VDI-Guideline 3940 (Determination of Odorants in Ambient Air by Field Inspections) describes a method of measuring odorants in ambient air. The effect on human smell is directly measured with this method. A parameter measured is the "percentage odor time" and represent the frequency at which observers can recognize an odor in the outdoor air.
Investigations that were done at dairy and cattle housing showed that representative results could be obtain with 10 plume measurements done during a year period to evaluate the distance at which the odor from a given livestock building can be recognized and "odor boundaries" can be defined. The odor boundaries measured are in general the same for the winter than for the summer. Different parameters have an influence on the intensity of substantial odor and they are: the topographic position of the livestock housing, the housing system, the fodder conservation and storage system and the manure system including the storage.

This publication is a practical example of application of the VDI 3940 for the determination of odor plume boundaries. The method and procedures used to evaluated the odor plume from a dairy and cattle housing are well presented and explained.
This odor plume determination technique could be used for any livestock housing.
See: VDI 3940 31 p. Kommission Reinhaltung der Luft im VDI und DIN.

Guideline to Assess the Protection Distance to Avoid Annoyance by Odour Sensation Caused by Livestock Husbandry.
Schauberger, G. (1) and M. Piringer (2)
1997b
Livestock Environment V. Volume 1. Proceedings of the Fifth International Symposium. Edited by Robert W. Bottcher, Steven J. Hoff. Published by the American Society of Agricultural Engineering. St. Joseph, Michigan. 49085-9659. P. 171-178
Austria
The Austrian guidelines are presented and compared to guidelines from Switzerland, Germany and the Netherlands. The comparison analysis is more complete in the publication presented
in: Assessment of the protection distance to avoid annoyance by odour sensation caused by livestock husbandry by Austrian guideline. 1997. G. Schauberger and M. Piringer

Swine Manure Odor Control Using Pit Additives - A Review
Zhu, J., D.S. Bundy, X. Li and N. Rashid
1997
Livestock Environment V. Volume 1. Proceedings of the Fifth International Symposium. Edited by Robert W. Bottcher, Steven J. Hoff. Published by the American Society of Agricultural Engineering. St. Joseph, Michigan. 49085-9659. P. 295-302
U.S.A
The literature is reviewed to provide the latest information on the development of pit manure products for the control of odor from manure. Problems that are currently being encountered in product designing and testing are presented. As the manure odor is composed of many different volatile organic compounds characterization is complicated. In past research, specific volatile acids have been identified as malodour indicators, however in recent studies, results show that such association may be misleading. An in-depth classification of the odorous compounds considering their inherent characteristics is needed. This lack of information on odours and odours compounds have contributed to the blind development of pit additive products and the fact that no a standard procedure for odour has been developed to scientifically evaluate pit additive products has restrain the development of knowledge on odour control by additives.
This publication is very interesting because it covers most of the work done on odor characterization of the odor compounds and also on the odor evaluation techniques.

Controlling Manure Odor Emission Using Covers
Liu, X.W., D.S. Bundy, J. Zhuand M. Huss
1997

Livestock Environment V. Volume 1. Proceedings of the Fifth International Symposium. Edited by Robert W. Bottcher, Steven J. Hoff. Published by the American Society of Agricultural Engineering. St. Joseph, Michigan. 49085-9659. P. 322-328
U.S.A
See: Malodour Abatement by Different Covering Materials. 1997. D.S. Bundy, X. Li, J. Zhu and S.J. Hoff

Utilizing Ammonia Concentration as an Odor Threshold Indicator for Swine Facilities
Liu, Q., D.S. Bundy and S.J. Hoff
1993
Livestock Environment IV. Fourth International Symposium. Coventry, England. 6-9 July 1993. p. 678-685.
U.S.A
The ammonia concentration and odor threshold levels were measured in the ambient air of four stages of the production unit and those measures were compared. Air samples were taken in different rooms of the building over a period of 11 months for odor threshold evaluation and the ammonia concentration were measured concurrently. The results of the comparison showed that the ammonia concentration is not a good indicator of the odor threshold when considering all production stages. However, correlation was obtained between ammonia concentration and odor threshold for the gestation and grower rooms within a given age group. Correlation could not be obtained for the farrowing and nursery rooms.
As mentioned in many publications, ammonia concentration cannot be used as an indicator of odor concentration. Even if the authors mentioned that ammonia could be correlated for gestation and grower groups, the pigs' age has to be considered and other testing would have to be done for different production management types (feed, manure handling inside, feed and water equipment).

Odor Control in Swine Houses by the Use of Natural Zeolites: First Approach to the Problem
Airoldi, G. (1), P. Balsari (1) and R. Chiabrando (2)
1993
Livestock Environment IV. Fourth International Symposium. Coventry, England. 6-9 July 1993. p. 701-708.
Italy
In Italy, the farmers in order to add natural Zeolites to the pigs diet: improve the feed efficiency, reduce the incidence of intestinal diseases, and lower the emissions of odor and ammonia from the manure produced. Natural Zeolites are tektosilicates that are characterized by a high Cation Exchange Capacity (as high as 300 to 400 meq/100g) and some Zeolites are known for their selective absorption of ammonium ions. Two trails were carried out in order to evaluate the real capacity of Zeolites to lower odor and ammonia emissions in ambient air of livestock buildings. The first trial was done on 2 groups of 200 fattening pigs one control group (no Zeolite in the diet) and one treatment group (phillisite at 5%). The control and treatment group were kept in 2 different rooms in the same building that was naturally ventilated and where manure was temporarily stored under the slatted floor. The second trial was realized in laboratory with manure where Zeolites were directly added to the manure at 2 different concentrations (5 and 10% of concentrates in the ration). In the first trial, no significant differences were measured for the ammonia emissions and for the feed efficiency; the improvement could not be economically justified. For 2nd trial, only manure treated with Zeolites concentration of 10% resulted in a reduction of the ammonia emissions.

This experiment was realized with an important number of pigs, which represent better the production conditions. The benefits from Zeolites addition to feed or fresh manure couldn't be proved as the ammonia reduction was not significant and the improvement in the feed efficiency noticed on the group fed with the 5% Zeolite ration was not significant also.

Farmer's Options to Reduce Odour and Ammonia Emissions from Animal Buildings and Storage
Voorburg, J.H.
1994
Animal Waste Management. REUR Technical Series 34. FAO, Rome. 1994. P. 5-17.
The Netherlands
For farmers, it is interesting to control ammonia and odour with a single measure. However, ammonia and odours have different impact regarding the environment thus the motivation for investments from farmers to control ammonia or odour are different. In the Netherlands were animal density is high, the control of both odour and ammonia became necessary as for other countries with lower animal density, odour is the first priority. As most measures to reduce emissions are not economically profitable, attention has to be given on measures that are applied where the emissions are important; as for the Netherlands the manure landspreading representing 1/2 the ammonia emission and a high proportion of the odour complaints. More effective proteins feeding will have an impact on the N excretion as urea and uric acid, thus lowering the ammonia concentration and emission. Housing systems that limit emission have also to be considered and the way manure is stored has also an impact. Outside manure tanks would be a better measure in reducing ammonia emission than in reducing odour emission. Housing systems with litter would result in odour control by lowering odor emission but not in the total N emissions (less ammonia but more NO, N2O than standard systems). Manure treatment have an effect on the emission however as anaerobic digestion reduces odour emission, it doesn't reduce ammonia emission and as acidification prevent the ammonia emission, it has little effect on odor. Measures that reduce ammonia emission cannot be automatically considered as being effective in odor reduction and conversely. The control of ammonia has to be regulated otherwise the farmers tend to consider odours as a higher priority.

Environmental Issues Resource Centre

Odour Management

This article gives a general view of the situation and means to reduce ammonia and odour emissions. The need for regulation on ammonia control is stressed as it is generally costly and odour control is considering the first priority with its direct impact on the neighbourhood.

Reduction of Ammonia, Compared with Odour Concentration on Pig and Poultry Farms
Amon, M.
1994
Animal Waste Management. REUR Technical Series 34. FAO, Rome. 1994. P. 51-58.
Slovenia

Experiments were done on a pig farm and included about 4850 piglets 24-86 days old and on a broiler chicken farm including about 16000 animals. The possibilities of reducing ammonia and odours by using "deodorase" additives in the feed and in slurry were investigated. Ammonia, hydrogen sulfide as well as other micro-climatic elements have been measured and olfactometric measurements have been done to determine the odour concentration obtained with the use of the additive (165g/t in prestarter feed, 65g/t for the grower and 15g/m3 slurry) compared to a control group. The results showed that for the pigs, the ammonia reduction was about 59% (significant at $P<0.001$) and the odour reduction was 22% but with no significant difference with the control group. It was found that there were differences in the reduction of ammonia and olfactometric values obtained between the pig and poultry farms (where for poultry the ammonia was reduced by 28% and the odour by 19.7%).

No information was given on the economical part of the additive use. The performance regarding odour cannot be considered in this experiment because no significant difference with the use of the additive (the difference of 22% could come from other experimental procedures and not necessarily from the additive). Even if the experiment was done with a large number of pigs, the experiment was not repeated.

Minimizing Emissions of Pig Husbandry Using Low Cost Biofilter and Bioactive Deep Litter
Meszaros, G.
1994
Animal Waste Management. REUR Technical Series 34. FAO, Rome. 1994. P. 65-69.
Hungary

Two different techniques, straw bale odour filter and deep litter of sawdust or straw were verified to evaluate their ability to minimize odour and slurry production. Two fattening periods of 21 and 19 weeks were done with 2 lots of 15 pigs to test first a 50 cm deep sawdust litter and then a 80 cm deep unchopped barley straw litter and both cycles were compared to the performances of 2 lots of 16 pigs housed on partly-slatted floor (control group). The air coming from the control section was filtered with a biofilter house made out of straw bales. The straw bale biofilter was effective in decreasing the pig smell by 50% and the deep litter were effective in controlling odour and reducing the slurry production.

The experiment done on a small scale give interesting results for the biofilter. Not enough information is given to judge on the odour reduction obtained with the deep litters. The use of a large-scale biofilter is not address so it is difficult to evaluate of its capacities in reducing odour from whole swine building.

Farmer's Option to Optimize Nutrient Efficiency and to Reduce Odour and Ammonia Emissions from Landspreading of Slurries and Manures
Nielsen, C.V. (1) and G. Steffens (2)
1994
Animal Waste Management. REUR Technical Series 34. FAO, Rome. 1994. P. 117-127.
U.K. and Germany

Optimization of manure application can have 2 economical incentives, which are to obtain optimal yields of high product quality and to save money by reducing mineral fertilizer inputs. On ecological point of view manure application optimization can avoid ground and surface water pollution, excessive nutrient enrichment in soil and excessive ammonia and odour emissions (particularly as odour emissions related to manure application can be smell further than odour emissions from building of manure storage). The most important options to optimize nutrient efficiencies and to reduce odour and ammonia emission are the following: fertilization done according to the crop requirement for N, P, K by limiting the application rate to the first element satisfied (generally P for swine manure) and using mineral fertilizers to complete the other elements requirements, land application shortly before the time of the crop's main nitrogen requirement, using favourable weather conditions (no frozen soil or snow cover, wet and cold), when possible rapid incorporation after spreading finally the use of application techniques which reduce odour and ammonia emissions.

General information is given on ways to optimize manure application economically and ecologically. These considerations are basic elements to be considered in landspreading. However some of the information given has to be applied to European conditions where the winter is in many areas milder than in North America.

Odours from Landspreading Livestock Wastes
Pain, B.F.

1994
Animal Waste Management. REUR Technical Series 34. FAO, Rome. 1994. P. 151-155.
U.K.
Air samples have been taken during or after manure spreading to realize olfactometry measurements and determine odour emission. The threshold value was evaluated and expressed as OU/m3. Compared to pig slurry landspreading with a vacuum tanker spreading directly on soil (VT), ploughing in manure immediately after spreading has reduced odour emission by 84%, deep injection reduced odour emission by 73%, shallow injection lower emission by 53% and low trajectory spreader with trailing hoses reduced odour emission by 38%. The following manure treatments also lowered odour emission compared to untreated manure even when using the VT application technique: 86% odour emission reduction for aerobic treatment, 84% for anaerobic treatment and 34% for mechanical separation. Crude protein-reduced diets could also have an impact on odour reduction as those diets lower the concentrations of odorous compounds in the slurry.

Odour emission can be reduced using different spreading techniques. This publication gives those reductions. No information is given on the combined effect of the spreading technique and the use of crude protein-reduced diets.

A Review of the Literature on the Nature and Control of Odors from Pork Production Facilities
Miner, J.R.
1995
Prepared for The Odor Subcommittee of the Environmental Committee of the National Pork Producers Council. 118 p.
U.S.A.
This review on odour covers many aspects. The chapters subject are presented as follow: Odor and Odor Perception, Psychological Impact of Swine Odors, Odor Detection and Quantification, Legal Mechanisms for Odor Regulation, Relation Between Local Climatology and Odor Transport, Sources of Odor Associated with Pig Production, Techniques of Odor Reduction and Their Applicability, Chemical and Biological Additives to Achieve Odor Reduction, Effect of Feeding/Diet on Odors from Swine Manure, Air Treatment Processes, Integrating Site Selection, Facility Design and Odor Control Technologies, Separation Distances and Land Areas: A Manure Nutrient Balances Approach, The Real Odor Control Questions, and Research Opportunities Having Potential to Reduce Odor Complaints.

When does Hog Odour Stink?
Thu, K.M.
1996
The Swine Industry at the Forefront of Environmental Issues. Proceedings of the Symposium. Saint-Hyacinthe, Quebec. September 1996. Faculty of Agricultural and Environmental Sciences. Macdonald Campus, McGill University. P.59-65
U.S.A.
The changes in the swine industry are presented as the number of swine producers decrease and the number of swine produced tends to increase. The production has also developed in area where few pigs were produced before such as North Carolina. As those changes happen enormous efforts have been made to understand the technical aspects of the production but no to little attention has been given to the understanding of how people and rural communities relate to those changes. Little effort has been given into understanding how odour objections relate to social factors, what is the nature of odour complaints from the perspective of the people complaining. In the expansion of the swine industry, in some case core social values of good neighbouring are being violated: honesty, respect, reciprocity and sharing an identity. The common denominator of the resistance organizations in many states is a view that the rights to enjoy family and property have been violated and they have little recourse against it.

This brings a good view of some of the social factors under the opposition to swine production expansion.

Odour Control is Possible
Barrington, S.
1996
The Swine Industry at the Forefront of Environmental Issues. Proceedings of the Symposium. Saint-Hyacinthe, Quebec. September 1996. Faculty of Agricultural and Environmental Sciences. Macdonald Campus, McGill University. P.67-75
Canada
Good management practices take an important place in odour control. Additives are not cost effective although they produce some improvement in the manure viscosity helping the handling. Zeolite added to the feed is probably the most cost effective additive as nitrogen losses are reduced and feed conversion is improved.

Aerial Environment in Animal Housing. Concentration in and Emissions from Farm Buildings.
CIGR. International Commission of Agricultural Engineering.
1994
Working Group Report Series No 94.1.
This report had for objective to provide scientists and advanced advisers with information and basic facts about the following subjects:

- production and dispersion of dust (airborne particles) and gases inside livestock buildings;
- emissions of particles (pathogens excluded), gases and odour from livestock buildings to their surroundings;
- practical and useful measurement methods of measuring the contaminants;
- effect of the contaminants on humans and animals;
- methods to reduce indoor production, concentrations and emissions of contaminants.

This report does not present information about emissions and engineering aspects of storage and manure handling inside or outside the building. And this report doesn't deal with animal comfort.

General information of the aerial environment in animal housing is well presented with the principal phenomena and the possible solutions available.

Quality Assurance in Olfactometry
Berglund, B., U. Berglund (1) and T. Lindvall (2).
1988a
Volatile Emissions from Livestock Farming and Sewage Operation. Edited by V.C. Nielsen, J.H. Voorburg and P. L'Hermite.
P.12-25
Sweden
The results presented are not from agricultural application. However interesting information is given on the quality assurance in olfactometry and on the factors that have to be considered to analyse an odour situation. Emphasis has been put on the odour measurement of the threshold level but the psychophysical dose-effect relationship is not linear (odour unit vs. odour strength). To have a complete ideal of the odour, odour quality and acceptability has to be of prime importance as those two factors give information that is not only perceptual but also related to social values. These factors have to be known as the perception of odour plays an important role in the generation of odor annoyance.
To improve the validity of odour measurements, a calibrated scale should be used to able to compare the results.

Interesting elements are given to help make a link between factors (odour level, intensity and acceptability) that have to be measured and odor annoyance.
Guidance is presented for conducting olfactometric measurements (e.g., detection thresholds) and odour measurements (psychometric scaling methods) with the aid of human observers. Both types of measurement require an olfactometer for controlling and/or generating the stimulus with a constant exposure capacity and an adequate temporal exposure capacity. Olfactometric control should include a common standard odorant for reference purposes. It is recommended that absolute detection thresholds be checked with a signal detection approach that always involves background air presentations. Odour measurement control should include not only a standard odorant but also a master scale system providing a calibrated scale of odour strength that permits comparison between investigations, observers, and study objects. Examples of scaling techniques are given and a master scale procedure is recommended in detail. Results from a field study of a waste treatment plant and the odour reduction achieved by a biological soil filter illustrate the use and benefits of the recommended techniques.

Sludge and Slurry Disposal Techniques and Environmental Problems - A Review
Berglund, S. (1) and J.E. Hall (2)
1988b
Volatile Emissions from Livestock Farming and Sewage Operation. Edited by V.C. Nielsen, J.H. Voorburg and P. L'Hermite.
P.60-72
Sweden and UK
A good review of the applications techniques is done discussing the advantages and inconvenient they present. The ways to reduce the odour impact of spreading are presented and an economical appreciation of the methods is given. The conclusion is that it is cheaper to apply the manure properly for odour control than to treat it prior to application.
Current methods of applying sludge and slurry are reviewed and desirable practices and equipment design features, which can reduce the potential for volatile emissions, are indicated. It is concluded that for livestock slurry in particular, low pressure and low trajectory applications with immediate incorporation or soil injection are more cost-effective at controlling these problems than treating slurry to remove odour prior to application to land.

A preliminary Assessment of Machines for Surface Spreading of Sludges and Slurries with Minimum Odour
Stroud, D.A. and V.R. Phillips
1988
Volatile Emissions from Livestock Farming and Sewage Operation. Edited by V.C. Nielsen, J.H. Voorburg and P. L'Hermite.
P.103-112
UK
This is good review of 15 spreading equipment is given and the result can help in the equipment selection has shown in the abstract.
Information was obtained on 15 different surface-spreading machines, the designs of which sought to improve on conventional machines, especially with respect to odour control. Nine different aspects of performance were identified and put in an order of priority. Each of the 15 machines was ranked on each of the 9 aspects of performance, and overall rankings were also

recalculated using various adjustments in turn, to examine the sensitivity of the overall rankings to different factors. Tractor-hauled tankers equipped with multi-tube applicators or with dribble bars were most suitable for surface-spreading sludge or slurry, with reduced odour. Cable-driven irrigators are also satisfactory where supplied directly by pipeline from the main slurry storage tank. Since availability of numerical data on the various machines was incomplete, these assessments must be regarded as preliminary.

Experiences with the Use of Biofilters to Remove Odours from Piggeries and Hen Houses
Zeisig, H.D. and T.U. Munchen
1988
Volatile Emissions from Livestock Farming and Sewage Operation. Edited by V.C. Nielsen, J.H. Voorburg and P. L'Hermite.
P.209-216
Drawing of biofilters is shown in the paper. For odour removal from pig housing, 50 cm thick of material is used and the biofilter can treat 290 m3/h of air per m2 of filter. Garbage compost and fibrous peat have been tested and the peat seems to be the best filter material as the porosity is high and the pressure demand is lower. Higher pressure demand will increase energy cost as the ventilator have to work harder to push the air through the biofilter. Such biofilter are relatively to maintenance however to assure good operation conditions de-dusting has to be done before the air enters the filter material and this material has to be kept moist (generally only during dry periods as the air coming from the building is relatively humid). No cost appreciation is given.
The use of biofilters is discussed with reference to German research and experience. Filter materials (incl. peat, bark compost, garbage compost) are discussed and their efficiency examined. Diagrams and specifications are presented for hen housing and pig buildings. The filter bed for pig housing is a fibre peat mixture with a thickness of 50 cm and an hourly airflow rate of 290 m3/m2 of filter bed. For hen housing a thickness of 50 cm and an hourly airflow rate of 400 m3/m2 of filter bed was used.

Rapport synthese - Inventaire et etude comparative des technologies de desodorisation et autres methodes et pratiques d'attenuation des odeurs de lisier
CRIQ, Universite Laval, Les Consultants BPR
1994
Dossier CRIQ no: 640-PE03364, Rapport Technique no: RDQ-94-040. Prepare pour le Ministere de l'Environnement e de la Faune. MEF. Quebec.
Quebec, CA
A comparative study on odor abatement techniques have been done to select the most promising avenues in manure deodorisation for Quebec conditions. The efficiency, the environmental, agronomical and economical impacts of those techniques have also been considered. A simulation model was constructed to include and process different parameters of the manure management chain. The analysis results show that for existing building, the use of biological feed additives, and the use of roofs or covers for the manure storage facility and injection for manure disposal are the more advantageous measures. For new building, biocontrolled litter proved to be very promising. Regional manure treatment centres become interesting when the manure has to be applied on fields that are further than 24 km from the farm or storage facility.

This study is quite interesting and complete on the current techniques available and the economics associated with their uses.

Odor and H2S Levels from Minnesota Pig Manure Storage Units.
Jacobson, L.D.
1997
In: Environmental Issues in Pork Production. The Allen D. Leman Swine Conference. September 20, 1997. Minnesota Extension Service. University of Minnesota. p. 44-55
U.S.A.
Considering the negative impact pig production can have on the neighbours by the odor emissions and also the concern in Minnesota associated with the state standard on H2S on ambient air (30 ppb for 1/2 hour not to be exceeded twice in 5 days or 50 ppb for 1/2 hour not to be exceeded twice in one year) a study was initiated (measurements done in the fall 1996 and the spring and summer 1997) to evaluate a variety of manure storage systems from around the state. The air samples collected in a floating "equilibrium" chamber were analyzed by a panel using and olfactometer to determine the odor concentration (odor units). And H2S measurements were done by a Jerome TM meter (for concentration lower than 20 ppm) and also using Sensidyne TM colorimetric detector tubes. The results collected from the different pig manure storage systems (40 in total divided into 4 types of storage: indoor deep pits (14), outdoor concrete/metal structures (8), earthen basins (14), and 2nd stage earthen basins (4)) did not show any advantage of a system over another when considering odor dilution thresholds and H2S concentrations. Variations seem to occur seasonally with odor levels higher in the spring and H2S concentrations higher in the fall. Further measurements will be done in 1997-1998 and more information will be available to help explain some variations.

This experiment will give valuable information about manure storage systems considering odor and H2S emissions and the possible seasonal variations. No system seems to present better performances but attention could be given to certain period of the year when the emissions are higher if some treatments or measures were to be considering for odor or H2S abatement.

Environmental Issues Resource Centre
Odour Management

Anaerobic Digestion - A Holistic Approach to Odor Control
Wilkie, A.C.
1997
In: Environmental Issues in Pork Production. The Allen D. Leman Swine Conference. September 20, 1997. Minnesota Extension Service. University of Minnesota. p. 30-36
U.S.A.
Odor is one of the primary public relations problems that have to face the livestock industry with the nuisance complaints and potentially damaging litigation. The solutions of this situation pass by the management of both odor and manure produced by the intensive livestock operations. An optimal manure management system should aim minimal environmental impacts and maximal resource recovery. The anaerobic digestion, realized under controlled conditions, presents a holistic treatment solution that control odors, produces usable energy, minimizes environmental impact and optimizes fertilizer, water recovery and reuse.

Considering the low cost of fossil fuels, this technique is not cost effective. However with the changes in the technology, the value of the secondary products (fertilizer, recycling of treated flush water) and possible incentive in the future to use renewable energy systems, the anaerobic digestion systems could become interesting.

County Human Health Concerns from Air Pollution
Bruns, J.L.
1997
In: Environmental Issues in Pork Production. The Allen D. Leman Swine Conference. September 20, 1997. Minnesota Extension Service. University of Minnesota. p. 56-58
U.S.A.
The Renville County's involvement in the Hydrogen sulfide testing of potential odor emission source is discussed as well as a proposed odor ordinance being developed by the county. Summaries of different U.S. studies are also presented on H2S and odor and their effect on health.

Odor Control Technologies
Bundy, D.S.
1997
In: Environmental Issues in Pork Production. The Allen D. Leman Swine Conference. September 20, 1997. Minnesota Extension Service. University of Minnesota. p. 59-65
U.S.A.
Results on different experiments are presented: alkaline by products (fly ash and cement kiln) added to manure, pit additives, organic and inorganic floating covers and land application. Livestock and poultry productions have an impact on air quality. However the density level which is not comparable to the one in some areas of several European Countries and the resulting ammonia emissions does not represent a threat to the vegetative growth as seen in Europe. Dust removal from exhaust ventilation air will reduce odor emissions. Regulations on odorous emissions from livestock production should focus on source reduction issues.

The information presented in this proceeding doesn't refer to any previous publication. It is difficult to analyze it as not much is given on protocol and test procedures.

A Low Cost Balloon-Type Lagoon Cover
Zhang, Y. and W. Gakeer
1996
1996 Annual Research Report, Prairie Swine Centre Inc.
Canada
To find solution to odour emissions from lagoon, a study was realized to verify the performance of a balloon type cover. A low-pressure blower keeps a positive pressure that inflates the balloon over the top of a lagoon. Proper installation methods as well as sealing of the perimeters of the cover were tested. Critical pressures were evaluated considering the wind conditions. The covers were effective for the control of odour emissions to the atmosphere. The approximate cost of such cover was approximately 6,000$CAN considerably lower those rigid wooden or steel structures.

Evaluation of Commercial Products for Odor Control and Solids Reduction of Liquid Swine Manure
Warburton, D.J.(1), J.N. Scarborough, D.L. Day, A.J. Muehling, S.E. Curtis and A.H. Jensen (2)
1981
Livestock Waste: a Renewable Resource. Proceedings of an International Symposium. American Society of Agricultural Engineering. 306-313
United States
Products from twenty-two companies that are designed to control odors and reduce solids in liquid swine manure were tested in addition to treatments done with: waste oil, activated charcoal, wintergreen oil, chlorine, mechanical aeration and an experimental product formulated at UIUC laboratories. A large panel of 40 to 50 persons were asked to rate odor on a 0-10

scale for odor strength and also for acceptability (parfume being high for strength and low for acceptability). The samples were put in black bottles covered with gauze to be rated by panel members. The results showed a large variability in the results. No fatigue of the panel members was observed as the clean water was always correctly identified and rated. The aeration treatment seemed to present the best performances in odor control however no significant differences could be measured between the different products and treatments. No differences were also observed for solids reduction.

Odor and Odor Policy Criteria
Schmidt, D. and L.D. Jacobson
1995
AEU-11. Minnesota Extension Service. Depart. Of Biosystems and Agric. Engineering. Univ. of Minnesota. Electronic document: www.bae.umn.edu/extens/aeu/aeu11.html. 6 pages
United States
Very general information is given on the odor and gas emissions, human health and perceptions, odor control technologies and measuring methods. The criteria for establishing policies on odor are presented. Those policies can be either based on actual odor emission, on separation distances, on odor emissions modeling and finally on nuisance complaints.

Identification and Measurement of Volatile Compounds Within a Swine Building and Measurement of Ammonia Evolution Rates From Manure-Covered Surfaces
Miner, J.R. (1), M. D. Kelley and A.W. Anderson (2)
1975
Managing Livestock Wastes. ASEA Proc-275. p. 351-353
United States
Air samples are taken in the vicinity of livestock production facilities and trapped for chromatographic and mass spectrographic analyses. From samples taken in swine buildings, thirty different compounds were identified and for eight of them the concentration was determined. A sampling box has also been developed for ammonia emission measurements from earth, building, and treatment surfaces. This sampling box allows also for total gaseous emission capture for a define area and a specific sampling period.
Details are given on the equipments and methodology used.

Managing Odors from Swine, Part 2 and Part 3
Nicolai, R.
1995
Electronic documents: gaia.ageng.umn.edu/extens/ennotes/enwin95/odors.html, 2 pages
gaia.ageng.umn.edu/extens/ennotes/enspr95/odor2.html, 1 page and
gaia.ageng.umn.edu/extens/ennotes/ensum95/odor3.html, 1 page
United States
This is a general overview of current method to reduce swine manure odors.

Areas discussed are buildings and facilities, outside storage systems (lagoons and covers,), and land applications (spreading and injection).

Deodorization of Swine Sewage by Addition of Phototropic Bacterium, Rhodopseudomonas capsulata
Lee, M.G. and M. Kobayashi
1992
Soil Science Plant Nutrition, 38, 767-770, 1992
Japan
Swine feces generate substances with an offensive odor composed of volatile fatty acid and hydrogen sulfide. A phototropic bacterium, Rhodopseudomonas capsulata, plays an important role in preserving water in its natural habitat.
Rhodopseudomonas capsulata, a bacteria isolated from pond-bottom ponds, has been used in wastewater treatment. It has been suggested that the bacteria plays a role in the utilization of volatile fatty acids (VFA) that contribute to offensive odour. Laboratory testing has been done to verify if the bacteria could lower the VFAs emissions when mixed to swine sewage. Under controlled conditions, gas sampling was taken from the headspace of swine sewage incubated with the bacteria. The results obtained showed that the amounts of VFAs could be reduced.
The tests were done under controlled conditions in laboratory with synthetic sewage manure. Further testing on swine production facilities should be done to verify if such treatment is efficient on production scale.

The Potential of Thermophillic Anaerobic Fermentation for Biological Methane Production and Odor Control Using Swine Manure as a Substrate
Williams, C.M.
1995
1995 Annual Report, Department of Animal Science, College of Agriculture and Life Sciences, North Carolina State University. Electronic document: www2.ncsu.edu/ncs...ep95/swine/swin9514.html
United States

Swine manure from primary treatment lagoon sediment and from rumen fluid was fed to methanogenic culture under thermophilic conditions (50°C). Biogas was produced successfully at a rate of 300L/kg volatile solids fed. 60% of the biogas produced was methane and the biogas yields remained stable. A panel on the digested manure to evaluate the odor intensity, irritation intensity and pleasantness did odour analysis. Considering the odour parameters, no significant differences were measured between the digested manure and the untreated manure.

Control of Manure Odors
ASEA, American Society of Agricultural Engineers
1997
ASEA EP379.1 DEC96. ASAE Standards 1997. Standards Engineering Practices Data. Reaffirmed for one year 1996. p. 642-643.
United States
This is a general summary of methods to control manure odor. This includes source and identification of odorous gases and vapours, techniques to minimize the formation of odorous gases and managing animal enterprises for odour control.

Evaluation of a Wind Powered Aerator to Control Odours from a Liquid Manure Storage
Toombs, M.R.
1997
Final Report. May 20, 1997. Ontario Ministry of Agriculture, Food and Rural Affairs. 14p.
Canada
Two liquid storages on the same site received the same finishing hog manure. One of the storages was the control while the other was aerated by a wind powered mechanical system. Samples were taken at day 0, 45 and 90. Liquid samples were analyzed for BOD5; aerobic and anaerobic plate counts, total N, ammonia, and total suspended solids (TSS). Odour samples were taken at the same intervals and evaluated using as dynamic olfactometer to determine odour threshold values. Air samples taken at the start and end of the evaluation were monitored for ammonia, methane, total phenols, volatile fatty acids (VFA) and hydrogen sulphide.

Differences between the two storages were evident from the first two sets of tests. Higher odour emission potential from the control storage coincided with high BOD, phenolic and VFA concentrations. VFA was a good indicator of odour offensiveness. The test storage average level of 113 mg/l after 90 days was well below 230 mg/l, the level considered to be associated with offensive manure odours. The test storage BOD was 535 mg/l, a reduction of 23% after 90 days. The range of TSS in the test storage at various depths was greatly reduced indicating a well agitated and aerated manure storage. Flux chamber results did not coincide with odour emission potential tests. Possibly due to a 3 degree Celsius higher surface temperature in the test storage.

The wind driven aerator effectiveness maintained the odour potential of the test storage below that of the control storage in spite of receiving fresh manure weekly. The aerator in this project is a cost effective means of controlling odours from liquid manure storage.

Reducing Odour and Noise Conflicts Between Rural Neighbours
Fraser, H.W.
1997
OMAFRA - Housing & Environment Factsheet. Agdex 711/538. Order 92-126. Last revised: 09/97. Also electronic document: www.gov.on.ca/OMAFRA/english/livestock/swine/facts/92-126.htm
Canada
General information and guidelines are given to reduce and deal with conflicts between rural neighbours considering that the rural population often does not have a direct link to agriculture anymore. Those problems can be odour or noise related. Five SMART methods (Separation, Magnitude reduction, Alteration, Reduction and Timing) are presented to reduce possible odour and noise conflicts. The necessary methods to solve complaints problems are also presented and they are: hearing both sides of the complaint; developing an abatement program; and follow up.

Analyse olfactive : du nez humain au nez electronique. (Olfactive Analysis : from human nose to electronic nose)
Hermia, J.
1997
Proceedings of the 4th International Conference on Characterization and Control of Emissions of Odors and VOCs. October 20 to 22 1997. Montreal, Qc, Canada. p. 2-20
Canada, QC
Smell plays a great role in our feeling of comfort and the appreciation of odour is greatly subjective. The human odour analysis is a very complex process linking the olfactive epithelium in the nasal cavity to the brain by nervous stimulation. For qualitative analysis the human nose is still the best tool and is reserved to "good noses". For quantitative analysis where the odour intensity is measured, the dynamic dilution olfactometer is the more accurate method for now. Using a panel of persons, odour dilution is done according to a specific protocol and the responses of the panel are analyzed to evaluate the odour intensity.

This method is in constant development and is considered a worldwide reference for normalization recommendations; odour units per m3 are used when odour intensity is evaluated.
In the last 10 years considerable work has been done to develop electronic noses. Many "chemical sensitive" materials with specific physical and chemical properties have been developed to react to the odour chemical components. With some materials, the reactions will produce a change in their electric resistance (MOS: Metal Oxide Sensor) or in their conductance (CP: conducting polymer) or with the QCM (Quartz Crystal Microbalance) and the SAW (Surface Acoustic Wave Sensor) a change in the oscillation frequency of the material will be measured depending of the mass of the adsorbed substance. The analysis of the signals obtained with these materials is very complex. In selecting and developing a nose it is important to consider if the results obtained are consistent over a number of samples, in time for a specific sample, and also for a sample from one machine to another (especially for comparisons between laboratories) and also to make sure that the nose is sensitive but robust and has a good lifetime. The results obtained with the nose have t be well analyzed and various methods are available.
The electronic noses are used in the food industry, the cosmetic industry and in environment to measure very specific chemicals.

This article is very interesting and gives a lot of information necessary to understand better all the processes in human smell and electronic nose. The dynamic dilution olfactometer is the method considered internationally as the electronic noses are developed for more and more applications.

General considerations for odor impact study
Page, T., C. Guy, and S. Vigneron.
1997
Proceedings of the 4th International Conference on Characterization and Control of Emissions of Odors and VOCs. October 20 to 22 1997. Montreal, Qc, Canada. p. 167-181
Canada, QC
The human nose is very sensitive and reacts rapidly to odor and also to variation in odor concentration. Odor impact studies has to consider this phenomena and the mathematical models used to evaluate odor dispersion has to be able to evaluate concentration fluctuations that occur close to the odor source because of turbulence and eddies. The eddies produce in plume fluctuations and also induce meandering. The classical Gaussian dispersion model (often used in air quality impact studies) cannot represent these phenomena by itself and has to be combining with another model to represent the meandering. The combination of the Gaussian and the Gifford model is discussed in this article.
Odor impact evaluation of a specific source is not only the results coming from a proper model. Results analysis has to be well done considering many aspects of the odor dispersion such as odor concentration and frequency of exposure and also the meteorological conditions producing such concentrations. The use of percentiles representing the percentage of time when the odor thresholds are exceeded can be a good way to represent the odor nuisance situation.

The article present well the odor impact studies however, The studies are more presented on a theoretical way with no link and validation with a real odor dispersion situation.

Ecosorb - Un neutralisant d'odeurs naturellement efficace
Denis, R.
1997
Proceedings of the 4th International Conference on Characterization and Control of Emissions of Odors and VOCs. October 20 to 22 1997. Montreal, Qc, Canada. p. 315-334
Canada, QC
This product, a mix of essential oils from different plants, seems to neutralize odors and has been used successfully in the food processing industry; waste treatment plans, composting facilities, refineries and petrochemical industries and foundries. The cost of this product seems to be very interesting compare to other expensive odor treatments and the product is harmless to the environment. This product has to be atomized in very fine droplets directly in the air or on the odorous product to neutralize the odor. Ecosorb is always used diluted and this dilution has to be done considering the odor source.

This product seems to be interesting however the text of this conference gives no reference to any specific testing done. Other documents may come later to complete this information. For now it is presented as the product to solve the odor problems but no real evidence is presented to support it.

A protocol for odour impact assessment
Nicell, J.A. and M.K. Tsakaloyannis.
1997
Proceedings of the 4th International Conference on Characterization and Control of Emissions of Odors and VOCs. October 20 to 22 1997. Montreal, Qc, Canada. p. 182-194
Canada, QC
An effective odour regulatory strategy meets other requirements then the current nuisance laws based on complaint or definition

of public nuisance and other regulation based on threshold measurements present. Odour Impact Model (OIM) is of interest because many parameters are considered including the impact of odours on the community. The impact of odours is judged on an emission base quantitatively (quantity and area affected using a mathematical model) and also qualitatively (degree of annoyance).

Very interesting in the review of current laws and regulations and their limits are presented. Shows the need for the development of regulations that gives a clear definition of the problem, gives and defines ways of measuring and addressing the odour problem (that are reproducible, low cost and effective) and consider the capacity (economical and technical) of the industry to control their emissions.

Traitement de melanges gazeux odorants (NH3 et H2S) par la biofiltration sur boues granulees. (NH3 and H2S odours treatment by granular sludge biofilter)
Turgeon, N. (1), J.-L. Fanlo (2), P. Lessard (3), G. Buelna(1) and C. Gracian(2).
1997
Proceedings of the 4th International Conference on Characterization and Control of Emissions of Odors and VOCs. October 20 to 22 1997. Montreal, Qc, Canada. p. 222-237
Canada, QC
A laboratory-scale biofilter filled with granular sludge (digested and dried) has been used to remove hydrogen sulfide (H2S) and also ammonia (NH3). The biofilter has been effective in removing 96% of the H2S for inlet concentration of less than 230 mg H2S/m3 with no acclimation period and immediate reduction. For the NH3, for concentration of less than 115 mg/m3, a reduction of 72% was measured but an acclimation period of about 6 to 7 weeks was necessary after the nitrifying bacteria seeding to obtain this level of reduction. Changes of the inlet gas concentration affected more the nitrifying bacteria than the sulphur bacteria as their counts showed.

The tests were done to verify the reduction of the concentration of only 2 gases and no link has been done to the verify the effect of these reductions to the final odor of the gas treated. No comment on the a large scale biofilter feasibility is done probably because of the performances of the nitrifying bacteria and the possible need of more experimentation to better understand their behaviour.

Desodorisation du lisier de porc par le procede de biofiltration sur support BIOSORmc (Swine manure deodorization by BIOSOR TM biofilter)
Buelna, G. (1), R. Dube (1), P. Lessard (2), F. Cotte (3), C. Gracian (3) and J.L. Fanlo (3)
1997
Proceedings of the 4th International Conference on Characterization and Control of Emissions of Odors and VOCs. October 20 to 22 1997. Montreal, Qc, Canada. p. 253-265
Canada, QC
A pig farm has been the site of testing of pilot-scale biofilters of 1 m3 and 2 m3 to optimize the BIOSOR TM process. The swine manure going through the BIOSOR TM biofilter is deodorized and treated. The organic bed is made of wood chips, peatmoss and shredded bark. The swine manure is decanted; the liquid part goes to the biofilter and the sludge part is kept in a decanter-digester. BIOSOR TM biofilter removes 95% of the polluting load of the liquid part of the manure and 95% of the odor load (for part of the ventilation air is treated, from the storage, from the transportation and the spreading).

This is an interesting technology but it needs improvement to be integrated easily in the agricultural practices. The digested manure (decanted part) has to be spread in the field the using manure applicator and for now, the treated liquid part has also to be spread because its treatment is not complete. This liquid cannot be directly disposed in a creek because of its remaining pollution load. The liquid and sludge part has to be stored until spreading can be done duplicating storage facilities. Work is now done to complete the treatment of the liquid part.

Etude de la dispersion atmospherique de composes volatils odorants: solutions proposees (Atmospheric dispersion of odorus volatil compounds: proposed solutions)
Guillot, J.M. (1), H. De Melo Lisboa (2), J.L. Fanlo (2) and P. Le Cloirec (3)
1997
Proceedings of the 4th International Conference on Characterization and Control of Emissions of Odors and VOCs. October 20 to 22 1997. Montreal, Qc, Canada. p. 159-166
Canada, QC
Software developed to study the odours dispersion is presented. This tool is developed based on Hogstrom theory of odours dispersion of puff emissions applied to Gaussian models. Concentration peaks are taken into account. ODODIS (Odours Dispersion Software) propose nine options within the Gaussian domain to explore different solutions for atmospheric dispersion problems for odorous as well as odourless gases using different input such as g/s, ppb and UO (unit odour). Testing for data collection and validation of the software has been done with a normal scale odour source (chimney giving off given concentrations of acetone, a gas easily measured) to control the emission and meteorological data acquisition station. Sampling collections were done at different locations few meters to the source and a database could be developed. Simulation was done

with the software to verify the ability of the nine solutions to evaluate correctly the concentrations at the sampling points. Two of the nine solutions proposed give interesting results that demonstrated that such application of Gaussian models could be satisfactory in estimating dispersion patterns rapidly.

This research is interesting because data collection was done and a database could be done to validate the proposed models. The use of a gas as source simplifies the data collection because the gas concentration evaluation is more easy and rapid than odour quantification. Further work done directly with odour would substantiate this project.

European Interlaboratory Comparaison Olfactometry - Experiences and Results of a Participating Laboratory
Both, R.
1997
Proceedings of the 4th International Conference on Characterization and Control of Emissions of Odors and VOCs. October 20 to 22 1997. Montreal, Qc, Canada. p. 345-358
Canada, QC
In 1992, at the demand of the European Committee for Standardization (Comite europeen de normalisation CEN) a working group was formed to develop a standard method to determine odour concentrations using dynamic olfactometry. Two years later a draft CEN Standard was presented and in 1995 the working group decided to validate these Standard by an international ring test. In the summer 1996, 19 European participants realized olfactometry tests using the developed CEN Standard. The procedures of the ring test are presented in the proceeding and n-butanol was used as odour source as its concentration can be measured and identical samples could be sent to the participant laboratories. The CEN Standard as the guideline VDI 3881 (Germany) provides precise description of the common olfactometric methods but it also gives quality requirements. Testing of all the elements of the Standard (dilution equipment calibration, panel selection and odour threshold measurement) was done in the "European Interlaboratory Comparison Olfactometry".
Panel selection is an important part in the CEN Standard as it has an important impact in the results obtained.

Olfactometry is an important tool in the determination of odour intensity of a specific source particularly when the emissions are constituted of many different compounds, which can't be chemically analyzed as a whole, and as the determination of the concentration of one or two components can't give significant information of the odour level of the mix. However olfactometry is a complicated process and the results depend greatly in the respect of specific procedures. The CEN Standard was developed so the used of a standard method could allow comparisons between laboratories and in time. This method could then be used to compare or develop odour control methods, products or policies through out Europe and elsewhere if the Standard is used.

European Interlaboratory Comparaison of Olfactometry - Overall results and implication
Harreveld, A.Ph. van (1) and P. Heeres (2)
1997
Proceedings of the 4th International Conference on Characterization and Control of Emissions of Odors and VOCs. October 20 to 22 1997. Montreal, Qc, Canada. p. 359-374
Canada, QC
The working group CEN/TC264/WG2 'Odours' has prepared a draft European Standard for olfactometry for the CEN (Comite europeen de normalisation). Before enquiry and voting, this method had to be validated and this process, an International Olfactometry Comparison (ICO), was realized by 19 European Laboratories (who had been vetted) in the summer 1996. The odour source used for the comparisons was n-butanol at concentrations ranging from 15 to 400 ppm/v equivalent to 375 to 10000 oue/m3 (European odour units). The Dutch laboratories (8) also tested a complex environmental odour at the demand of the Netherlands Council for Accreditation/Netherlands Calibration Organization (NKO). For n-butanol, 5 of the 14 audit-compliant laboratories met the quality criteria on accuracy and repeatability and for the tests done with the complex odour in Dutch laboratories, 2 out of 6 attained both criteria. Considering these results, the quality criteria set in the draft European Standard are attainable and the document will be forwarded by CEN/TC264/WG2 'Odours' for public enquiry among CEN organization members at the end of 1997 that should vote on it in 1998.
Even when meeting accreditation requirements, odour concentration measurement in the Netherlands is now 2/3 lower in cost compare to the 1980 level even with no consideration for inflation.

The results obtained in the ICO gave CEN/TC264/WG2 'Odours' enough confidence to recommend the draft European Standard for olfactometry to the CEN for voting. Strict methods and procedures have to be followed to meet the quality criteria and as stated in the proceeding, ongoing internal quality control in a laboratory is making a difference in meeting those criteria. As mentioned in another conference, the panel selection is very important because it has a direct impact on the results.

Caracterisation hedonistique des odeurs par la mesure des reactions neurovegetatives (Odor hedonics caracteristics by autonomic responses measurements)
Robin, O. (2), O. Alaoui-Ismaili, J. Chanel (1), G. Delhomme, A. Dittmar (3), S. Rousmans (1) and E. Vernet-Maury (3)
1997
Proceedings of the 4th International Conference on Characterization and Control of Emissions of Odors and VOCs. October 20 to 22 1997. Montreal, Qc, Canada. p. 375-393

Canada, QC
Experiments have been done to link the autonomic responses (such as cardio-respiratory frequency, skin potential, resistance, temperature blood flow) and the subjective verbal responses resulting of induced odors (pleasant and unpleasant ones). Each individual has preferred channels responses in one or two autonomic parameters and the protocol and equipment allowed the verification of these reactions and the classification of the individuals by their specific reactions.
The autonomic responses are more informative because they are more diversified than the verbal responses and give information about the affective state of the subject exposed to an odor. Also in some cases autonomic responses can be registered while the subject is not reporting odor detection. The proposed method can make the link between the subjective reactions obtained by the autonomic responses and the

Links are being made between odor perception and the affective state of the person exposed to a specific odor; links that are not often made with verbal comments. This is interesting because this type of research could better understand the affective reaction to long unpleasant odor exposure.

Surveying odor nuisance of a plant: purpose and practical guidelines. Case studies of sewage treatment plants.
De heyder, B. and A.S. Vandendriessche
1997
Proceedings of the 4th International Conference on Characterization and Control of Emissions of Odors and VOCs. October 20 to 22 1997. Montreal, Qc, Canada. p. 644-653
Canada, QC
A community odor survey can give more specific information about the nuisance coming from specific process operations in waste water plants. This tool can help define the frequency and the spatial distribution of the odor nuisance and by studying the results; links can be made to specific plant operations. Guidelines of the methodology and two case studies are presented. Such a survey has to be accepted and well announce within the community to assure a sufficient participation. The participant registered appreciation of the quality of the odor in the outdoor air (from no nuisance to severe nuisance) on an hourly basis when possible. Those responses were linked to meteorological data to know at least the wind speed and direction to determine the orientation of the odor dispersion.

This is an interesting tool to appreciate the spatial dispersion and the frequency of odor emission. The community could also link such a survey with dispersion model to add more information and also to evaluate the appreciation of the odor nuisance.

Characterisation of air extracted from pig housing: effects of the presence of slurry and the ventilation rate.
Guingand, N. (1), R. Granier (2) and P. Massabie (2)
1997
Ammonia and Odour Control from Animal Production Facilities. Proceedings of the International Symposium. Vinkeloord, The Netherlands. October 6-10, 1997. P.49-55.
France
120 pigs fed the same diet (in 2 stages, growing and finishing) have been divided equally in 3 different groups for their growing-finishing stage and placed in 3 different rooms. In the room 1 the ventilation rate was 1500m3/h and the manure was stored under the slat during all the experiment, in the room 2 the ventilation rate was also 1500m3/h and the manure was removed every 40 days and in room 3 the ventilation rate was 750 m3/h and the manure was stored. Air samples were taken in the 3 rooms the day after the manure had been removed in the room 2 and were analyzed to evaluate the concentration of some odorants compounds (chemical analysis) and the odour emission (olfactometry). The nitrogen compounds were the main compound group identified in the analysis: ammonia, aldehydes and ketones were present at low concentrations. The analysis showed that the concentration of nitrogen compounds and aldehydes were lower for the room where the manure wasn't stored under the slats. A reduction of 55% of the odor emission (odor rate) was measured when the manure is not stored for identical ventilation rates (room 2 vs. room 1). The room 3 was compared to room 1 (same manure management, half the ventilation rate in room 3 compare to room 1) showing that the ammonia and aldehydes concentration levels were lightly higher in room 3 and that the odor emission from room 3 was 29% lower than the one in room 1.

This experiment is interesting but no replicates were done to assure the validity of the results. Also it becomes a bit confusing because the results analysis are presented in term of concentrations for the chemical compounds and in term of production rate in term of odour which are 2 different things, the rate being the concentration multiplied by the ventilation rate. Even if the concentration is higher if the ventilation rate is low, the emission rate can be lower. The emissions in this case don't give an exact information on the inside conditions.

Electronic nose evaluation of synthetic hog farm odor.
Classen, J.J., S.S. Schiffman, H.T. Nagle and R. Gutierrez - Osuna
1997
Ammonia and Odour Control from Animal Production Facilities. Proceedings of the International Symposium. Vinkeloord, The Netherlands. October 6-10, 1997. P.77-82.
U.S.A

Testing of an electronic nose using conducting polymer sensors was done to measure the detection threshold of acetic acid in water, acetic acid in oil and also of synthetic pig slurry composed of ten organic compounds. A human odor panel also analyzed the same odor samples. The nose performed well in the evaluation of acid acetic in oil but important differences were obtained between the results of the nose and the one of the human panellists for the water-based solutions due to the humidity from those solutions. Different approaches and mathematical analysis were used and evaluated for their ability to simulate the discrimination of the human panel. For the experiment conditions, Fisher's Linear Discriminant Analysis gave the best performance. However any changes in the experimental set up that would have an impact on variability would necessitate re-evaluation of the approaches and analysis.

The electronic nose is a tool that is not yet ready for odor analysis of slurry. However, such a tool will be very valuable when its ability to reproduce human olfactory reaction will be improved as costly olfactometry analysis could be replaced by in situs analysis with a nose.

ILES II
First Trials of Swine manure Odor Control with Depth Aeration and "Oligolyse"
Chiumenti, R., L. Donantoni, and S. Guercini
1987
Seminar of the 2nd Technical Section of the C.I.G.R. on: Latest Developments in Livestock Housing. Urbana-Champaign, Illinois. June 1987. p. 23-33
Italy
Two odor control methods, aerobic deodorizing and oligolyse, were tested for a 120 days period on two different farms having a production of 1500 to 2000 fattening pigs a year. The manure was stored outside the building in a storage basin for the aerobic deodorizing and inside in a pit under the slatted floor for the oligolyse treatment. The aerobic deodorizing consisted of aeration made by 4 aerators (2 submersible pump types and 2 screw types) working on 20 minutes/hour cycles. The oligolyse is a process where an electric potential is created between an copper electrode and a coal one that are placed at a certain distance in the manure. As a result, metallic cations are released from the copper electrode into the manure. Those cations have a sterilizing action on the microorganisms responsible for anaerobic fermentation and malodorous gases production. Results showed that both systems reduced significantly the smell of the manure compared to the untreated on. However, the oligolyse cost 40 to 45% less than the aerobic deodorizing when considering energy cost, and fixed costs.

This experiment was done on only two different storing facilities with no replicate. The results obtained are interesting but more experiments are needed to verify those results. The agronomic value of the manure treated with oligolyse has also to be determined as copper cations are added in the process.

Inst. & Cent. 1a
Sensing odours - the electronic nose
SRI, Silsoe Research Institute
1995b
Annual Report 1994-1995. Silsoe Research Institute, Wrest Park, Silsoe, Bedford, MK45 4HS. Pp. 40-41
England
A sensor is being developed using a highly sensitive new polypyrrole-based material, which detects odorant levels of less than 1 ppm. In the development of the sensor, the data manipulation and interpretation are as important as the development itself to fulfill the electronic nose capabilities.
The sensor response has shown that distinctive patterns are identifiable and associated to different types of pig manure. These positives results could help linking odour to chemical compounds with the use of the electronic nose.

More research should be done on this type of technology to give and reliable and easier way of evaluating odours. Quite a bit of work has to be done to reach that point.

Inst. & Cent. 1b
Waste engineering
SRI, Silsoe Research Institute
1995a
Annual Report 1994-1995. Silsoe Research Institute, Wrest Park, Silsoe, Bedford, MK45 4HS. Pp. 36-37
England
Waste engineering in Silsoe covers many different projects related to the reduction of emission and pollution control. This research team is very active and their work is centred on the understanding of the processes involve in emission and pollution.
- Experiments were conducted with a novel Odours and Emissions Chamber (OEC) to collect data on different factors (temperature, wind speed and slurry mixing) affecting emissions. Those data will be used in mathematical models. As an example, they fund that with a wind of 1 to 5 m/s ammonia emissions from exposed pig manure surface can be as high as 3 to 5 g/m2-day. OEC has also been used to measure the methane emissions from the grazing animals' dung and urine and the highest emissions can be measured for wet, warm and high wind conditions.

- Aerobic treatments of pig manure have also been tested. Except for the pathogen numbers reduction, the continuous treatment is more interesting when it comes to cost, control and consistency. Chemical Oxygen Demand (COD) can be reduced to almost 50% by a 20 days mesophilic (20-40 C) treatments as for a thermophilic (50-60 C) aeration the diminution in COD is not significantly different but this process lead to up to 25% of nitrogen lost as ammonia emissions. Continuous mesophilic treatments or at least 3 days with sufficient aerated regimes enable the nitrification of almost all the ammoniacal nitrogen by conversion to nitrites or nitrates. However 70% of the original nitrogen in the manure can be denitrified and lost emissions of gaseous nitrogen or nitrous oxide when the aeration regime is lower or periodic.
- New techniques have been developed such as a manure analysis by high performance liquid chromatography and for gaseous measurements during denitrification, a mass spectrometric method.
- A stratification treatment process, which aerates the manure, has been tested and the manure can be recycled for excreta flushing in the swine building resulting in a reduction of the ammonia concentrations by 50%.
- Packing materials have been tested to minimize the cost of biofilter that are used to treat the ventilated air from the animal buildings. The materials are selected considering their good biological performances and the low-pressure gradients they produce.

Their research programs are very interesting and cover many aspects of environmental control by studies and treatments on emissions and manure treatments. This research team seems to be well connected to the research made in Europe with their joined projects with other countries.

OD 00-01
Odor Carrying Characteristics of Dust from Swine Facilities
Wang, X., P.G. Stroot, Y. Zhang and G.L. Riskowski
1998
Paper 984068. 1998 ASAE Annual International Meeting. July 12-14, 1998. ASAE, 2950, Niles Road, St.Joseph, MI 49085-9659. 11p.
United States
Odour complaints represent a large number of the complaints centred around intensive swine production units. Previous studies have shown a correlation between odour and aerosol particles from dust buildings but three fundamental questions till need to be answered: what types of compounds make dust unpleasant? How much odour does it carry? What sizes of particles carry the most odours? Through the use of gas chromatography results show there are approximately 70-100 volatile compounds absorbed on dust, as well shows similar compounds between grower and finisher units with respect to peak retention time. These compounds are similar in winter and summer months, however their peak retention time varies between seasons. As well, the study indicated all retention times of all major compounds was less than 22 minutes, indicating that indolic compounds are not associated with dust or feed.

OD 00-02
Odor Emissions from Swine Nursery Buildings
Lim, T.T., A.J, Heber and J.Q. Ni
1999
Paper 994147 1999 ASAE Annual International Meeting. July 18-21,1999. ASAE, 2950, Niles Road, St.Joseph, MI 49085-9659. 12p.
United States
Odour generates the largest number of complaints with respect to intensive livestock operations, however the measurement of baseline odour levels is not widely available. This study intended to measure building odour emissions and gain further information for the development of odour impact guidelines for the pork production facilities. In order to achieve this two objectives were established: measure odour concentration and emission from pig nursery facilities and assess the intensity and offensiveness of odour emitted by swine nurseries.

Two mechanically ventilated nurseries were used to measure odour concentration and offensiveness between March and May 1999. Odour threshold values were determined by a dynamic dilution, forced-choice olfactometer. The results indicate a relatively low sampling variance, with odour concentration of pit fans ranging from 94-635 OU averaging 190 OU. Outdoor odour concentration levels averaged 23 OU ranging from 7-85 OU. The arithmetic odour emission rate was 53% of the emission rate reported by Heber (1998) for swine finishing barns. While on the building floor area, the geometric mean of building odour emission was 42% of the value measured by Heber (1998) for finishing buildings. It appears that finishing pigs emit about 90% more odours per animal unit and 140% more per unit area than nursery pigs. Manure depth also seemed to positively influence the odour emission rate. Greater manure depths encourage more anaerobic microbial activities, which cause production of more odorous gases.

OD 00-03
Odor and Gas Reduction from Sprinkling Soybean Oil in a Pig Nursery
Jacobson, L.D and L.J. Johnston
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- Aerobic treatments of pig manure have also been tested. Except for the pathogen numbers reduction, the continuous treatment is more interesting when it comes to cost, control and consistency. Chemical Oxygen Demand (COD) can be reduced to almost 50% by a 20 days mesophilic (20-40 C) treatments as for a thermophilic (50-60 C) aeration the diminution in COD is not significantly different but this process lead to up to 25% of nitrogen lost as ammonia emissions. Continuous mesophilic treatments or at least 3 days with sufficient aerated regimes enable the nitrification of almost all the ammoniacal nitrogen by conversion to nitrites or nitrates. However 70% of the original nitrogen in the manure can be denitrified and lost emissions of gaseous nitrogen or nitrous oxide when the aeration regime is lower or periodic.
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OD 00-03
Odor and Gas Reduction from Sprinkling Soybean Oil in a Pig Nursery
Jacobson, L.D and L.J. Johnston
1998

Paper 984125. 1998 ASAE Annual International Meeting. July 12-16, 1998. ASAE, 2950, Niles Road, St.Joseph, MI 49085-9659. 9p.
United States
Daily sprinkling of small amounts of soybean oil inside a pig nursery facility reduced odour, H2S and total dust levels of the air inside the barn and in the emission or exhaust ventilation air. Oil sprinkling, as outlined in the MWPS AED-42 publication (40 ml/square meter for the first 2 days, 20 mlk/ square meter for days 3 and 4 and 5 ml/square meter for the remaining time the pigs were in the room. Once every 2 weeks a surge amount of 20 ml/square meter would be added), was not effective in reducing ammonia concentrations or respirable dust levels inside the treatment barn when compared to a similar control barn.

OD 00-04
Effects of Organic Cover Biofilters on Odors from Liquid Manure Storage
Zhang, Z, T.L. Richard and D.S. Baine
1999
Paper 994087 1999 ASAE Annual International Meeting. July 18-21,1999. ASAE, 2950, Niles Road, St.Joseph, MI 49085-9659. 11p.
United States
Odour complaints are the single largest source of complaints with respect to intensive livestock operations. One method of odour reduction is the use of a biofilter. These low-cost filtration systems have been successful in reducing hydrogen sulfide and odour emission levels from livestock operations.

This study set out to examine the impact of a manure-soaked straw cover, water-soaked straw cover and a dry-straw cover on the odour and hydrogen sulfide emissions generated from a manure storage unit. Two trails were completed to evaluate the biofilters, the first trail lasted from April 1 - May 4, 1998 and the second trial lasted from June 4 - July 23, 1998. All samples were analyzed for hydrogen sulfide and odour threshold levels.

Hydrogen sulfide levels were influenced by two factors: diffusion of the odour through the biofilter and dilution by the fresh air flowing across the surface of the biofilter. The average hydrogen sulfide reduction for the first trial (April 1 - May4) from the straw soaked with manure was 95% and the straw soaked with water realized a 91% reduction. During the second phase of the trial the dry straw cover was compared with the water-soaked straw cover. Average hydrogen sulfide concentrations at the surface ranged from 1,145 - 2,037 ppb at the manure surface and 110 - 115 at the outlet for the dry straw cover. Representing a 92% H2S reduction rate. The wet straw cover averaged 573 - 847 ppb at the manure surface and 101 - 153 ppb at the outlets, representing an 81% reduction in concentration levels. The average H2S reduction of the control, no straw cover was 50% between the manure surface and the outlet.

Odour reduction with the wet straw was 55% while the straw soaked with manure was 45%. The manure soaked cover odour reduction was not as high because the manure in the straw contributed to emitting odours. Odour reduction levels were reduced 59% with the dry straw cover. The hydrogen sulfide and odour concentrations were not as high in the second study. This can be explained by the summer testing period, in which the higher temperature would increase microbial activity and therefore increase the amount of hydrogen sulfide and odour being emitted from the manure.

OD 00-05
Evaluating the Use of Straw and Other Floating Materials to Control Odor Gases from Pig Manure Storage Units
Jacobson, L.D., D.R. Schmidt, R.E. Nicolai and C.J. Clanton
1999
Paper 994134, 1999 ASAE Annual International Meeting. July 18-22, 1999. ASAE, 2950, Niles Road, St.Joseph, MI 49085-9659. 5p.
United States
This study demonstrated that straw applied to outdoor manure storage and other floating covers can effective reduce odour and H2S emissions from these units. These covers are cost effective, ranging in price from $0.08 per square foot for straw cover or $0.40 per square foot for a more permanent geotextile cover. However, these covers are not without their challenges. The length of time the straw covers stayed afloat varied accordingly to factors like rainfall, depth of manure storage, surface area and manure characteristics. As well, larger manure storage units increase the difficulty in applying the straw in an evenly distributed pattern. During the manure removal process, additional agitation may be required in order to incorporate the straw in the manure.

OD 00-06
A Better Understanding of Odour
Manitoba Livestock Manure Management Initiative
1999
Initiative Newsletter. Winter 1999. Volume 2, Issue 2. P. 1
Canada
Odours generated from intensive livestock operations are growing in public concern and in many cases can limit location of

newly built facilities. Recent work by Kenneth Adams of Reid Crowther studied the distribution of odour plumes generated from hog buildings. Odour plumes were determined to be very narrow, and dependant on wind and weather conditions. Information gathered from this study will assist engineers in using prevailing wind patterns to assess most suitable location for new swine buildings.

OD 00-07
Eating Odours with Biofiltration
Manitoba Livestock Manure Management Initiative
1999
Initiative Newsletter. Winter 1999. Volume 2, Issue 2. P. 2
Canada
Recent work at the University of Minnesota suggests that biofiltration may effectively reduce odour concentration generated from intensive livestock operations. Exhaust gas generated from mechanically ventilated swine buildings is passed through a biofilter, such as a loam, peat or compost allowing the air to filter or percolate through the material.

OD 00-08
A Sense of Swatch
Manitoba Livestock Manure Management Initiative Inc.
1999
Initiative Newsletter. Winter 1999. Volume 2, Issue 2. P. 2
Canada
An initiative-funded strategy by Manitoba Livestock Manure Management Initiative is gathering collection information used in collecting air samples to measure odour. Roberta York is working on a system that collects odour samples on swatches of fabric. Currently different types of fabric are being evaluated to determine which has the best structure to capture odour. According to York, " this will give us a standardized method of objective sensory testing." A small circular swatch of fabric is inserted into a cylindrical container, which is attached to a hand-held pump. This pump draws air through the swatch and seals the odour sample in the container, and the odour would be quantified in the lab through olfactometry. According to York, this provided everyone an inexpensive test; researchers, engineers and others will be able to study odour samples more easily.

OD 00-09
The Determination of Aereal Extent of Odour Plumes from Large Hog Facilities in Manitoba
Adams, Kenneth
1999
Personal Contact, Reid Crowther & Partners Ltd.
Canada
The study proposed to document, under various weather conditions (wind direction, velocity, temperature and humidity) and times of the year, at what distances odours from six existing larges hog operations are detectable. In addition, it was our intent to delineate the odour plume so as to provide useful information in locating future hog facilities; in providing scientific evidence to refute unsubstantiated odour complaints; and, to evaluate odour-controlling effectiveness of various types of manure storages; wind screens (trees or wind break(s) or terrain features. Six (6) large facilities within the hog producing area of southern Manitoba were included in the study; two in relatively flat terrain with few or no trees; two in relatively flat terrain with considerable bush; and, two in relatively rolling terrain preferably one with few or no trees and one with considerable bush. Because olfactory senses are possibly still the best and most often used indicator of the relative strength of odours, we choose to use a two-person 'odour-panel" to rate the relative strength of a particular odour on a scale of zero to ten. Public roads and municipal maps were useful in siting studies for large hog operations. Unfortunately, winds in Manitoba and for that matter most places can be experienced out of any direction; and, as a result odours from a large hog facility might be experienced at various strengths anywhere 360 degrees of the facility. With this in mind, however, these data combined with wind data for a particular location should be useful in explaining the probability and frequency that neighbours might anticipate odours from a planned hog facility

OD 00-10
Removal of Malodorous Compounds from Liquid Swine Manure by Subsurface Constructed Wetlands in a Greenhouse
Wood, S.L. and E.F. Wheeler
1999
Paper 994029, 1999 ASAE Annual International Meeting. July 18-22, 1999. ASAE, 2950, Niles Road, St.Joseph, MI 49085-9659. 13p.
United States
The relationship between two wetland systems (planted, unplanted) and their relationship to concentration of three malodorous compounds (dimethyl disulfide, ethyl acetate, p - cresol) was studied. Eight subsurface flow wetlands (4 planted, 4 unplanted) were treated liquid swine manure that was filtered through bark bed in order to reduce the total solids content. A human sensory panel was set up to evaluate the wetland effluent odour, and the reduction of the malodorous gas compounds was quantified using gas chromatography.

ANOVA analysis revealed a significant decrease in malodorous compounds in the planted wetland plots relative to the unplanted plots. On average, the planted wetlands removed between 60 - 80% of malodorous compounds, while the unplanted plots removed between 35 - 70%. Sign tests of the odour panel indicate the intensity level ranking was <1 for the planted wetland structure, signifying no objectionable effluent smell from the filtered swine wetland effluent. In conclusion, planted wetlands outperformed unplanted wetlands at removing malodorous compounds from liquid swine manure and producing wetland effluent that was not objectionable to the sensory panel.

OD 00-11
Swine Manure Control by the TOAST Aerobic System
Goodrich, P.R. and J.J. Petering
1999
Paper 994057. 1999 ASAE Annual International Meeting. July 19-21, 1999. ASAE, 2950, Niles Road, St.Joseph, MI 49085-9659. 9p.
United States
A full scale TOAST (Tertiary Oxygen Activated System Treatment) was constructed and evaluated in Southern Minnesota. The objectives of this system was to determine the odour reduction potential for a completely aerobic treatment system with the use of high pressure vessels, determine the system management characteristics and determine the energy required to operate the system in order to reduce odours. Air samples taken at the fan outlet were taken and odour thresholds were determined through olfactometry. The odours in the treated barn were significantly lower with approximately a 50% reduction in the treated barn. Hydrogen sulfide emissions and odour units were both greater in the untreated barn, with odour units being twice as high in the control barn. Additional electrical costs associated with the project were based on additional kilowatt usage. The TOAST system would cost approximately $9.60 /day to operate with a facility size of 300 animal units.

OD 99-01
Solutions to Reduce Ammonias Levels in Swine Facilities
Meyer, Daniel J.
1985
Proceedings from the fifth International Symposium on Agricultural Wastes, December 16-17, 1985
United States
Excessive ammonia levels within an operation can adversely impact pig performance through altering metabolic reactions or pig health; as well creating an unfavourable working environment for its staff. Three options were examined in the reduction of ammonia levels: (1) dilute the ammonia through higher ventilation rates (2) remove the ammonia before it reaches the pigs (3) eliminate the cause of the ammonia. Ammonia levels were studied in a variety of building designs to assist the reader in experiencing methods of reducing ammonia in different systems.

OD 99-02
The Potential of Thermophillic Anaerobic Fermentation for Biological Methane Production and Odor Control Using Swine Manure as a Substrate
Williams, C.M. (Mike)
1995
1995 Annual Report, Department of Animal Science. College of Agriculture and Life Sciences, North Carolina State University
United States
Interest in anaerobic digestion stems from its ability to address environmental concerns, including odour. However, there has been very little scientific data available regarding the efficiency of anaerobic digestion for odour control. The basis of this laboratory-scale experiment was (1) to determine the feasibility of biogas generation using swine manure as the sole substrate under thermophilic (50 degree Celsius) anaerobic fermentation treatment conditions and (2) to determine the effect of thermophilic anaerobic treatment of swine manure on odour intensity, irritation intensity and odour pleasantness. The results indicated odour intensity and irritation were not improved by thermophilic anaerobic digestion, odour offensiveness was reduced, and however the reduction was not significant.
The potential for biological methane production from swine manure, under thermophilic (50 degrees Celsius) conditions, and the impact of the process on odor parameters was investigated in the laboratory. A methanogenic culture was systematically enriched from a variety of environments including swine manure, primary treatment lagoon sediment and rumen fluid. The culture was successful in producing a biogas yield of approximately 300 1/kg VS fed. The methane fraction of biogas produced exceeded 60% and biogas yields were consistently stable. Analysis of digested manure effluent for odor parameters (via odor panel evaluation) showed no significant reductions in odor concentration or improvement in odor quality.

OD 99-03
Livestock Odor Control Additives: Effectiveness and Laboratory-scale Protocol For Evaluation
Williams, C.M. (Mike)
1995
1995 Annual Report, Department of Animal Science, College of Agriculture and Life Sciences, North Carolina State University

United States
A neutralizing agent, oxidizing agent, absorbent, digestive deodorant, and chemical additive were evaluated for their potential to improve odor parameters associated with liquid swine manure. A simple laboratory-scale protocol was utilized for the analysis. Results showed: 1) that the neutralizing agent improved odor quality, 2) the oxidizing agent reduced odor intensity and improved odor quality, and 3) the absorbent, digestive agent, and chemical absorbent did not significantly improve odor parameters under the environmental conditions tested.

OD 99-04
Managing Odors from Swine Waste AEU-8
Nicolai, Richard E.
1996
Department of Biosystems and Agricultural Engineering, University of Minnesota Extension Divison
United States
Odours are difficult to measure as well to manage. As we see an increasing trend to more intensive livestock operations odours will become a larger issue that must be dealt with. The most effective way to control odour is to identify the source and take corrective action to eliminate it. Odour sources can be divided into three categories: (1) building and facilities (2) Outside storage systems (3) land application. Sources of odours in and around buildings include: wet dirty floors and spilled, mouldy feed to name a few. The solutions for building odours can be based on best management practices, keep the facilities clean. Management also plays a key role in the management of odour of lagoons: control the pH and cover whenever possible. Land application should include direct injection, as well taking into account prevailing winds on days of application. Producers must recognize, how odour affects individuals is based on perception, therefore must develop a sensitivity and effective response to neighbours perceptions.

OD 99-05
Manure Application: Odor and Realted Nuisances
Comfort, Steve
1997
University of Nebraska-Lincoln, Department of Agronomy, Volume 3, No 6
United States
Related problems with manure application will never be completed eliminated. However, good manure management practices can be used to keep the odour associated with application at tolerable levels. This article examines the potential areas where odours may be generated from a and examines practices that can be implemented for controlling odours during application. One key point the author points out; by running a clean operation that applies manure at the proper rate and by avoiding practices that promote odours, some of the imagined problems associated with land application of manure can also be minimized.

OD 99-06
Control of Gaseous Emissions from Livestock Buildings and Manure Stores
Hartung, J., V.R. Phillips
1993
Journal of Agricultural Engineering Resources. 1993, 57, 173-189
UK
Odour is becoming a subject if increasing public concern. The study examined the origin, number and quantity of trace gases that are emitted from buildings and manure storage, as well presented alternative solutions to prevent or reduce odour emitted from livestock operations. The focus was to examine measures in reducing gas emissions in particular, ammonia. The author presented five alternatives to aid in the reduction of odour: 1) the effect of feeding 2) understanding the properties of excreta 3) season and corresponding ventilation rates 4) manure removal rates and 5) alternative feed and pit additives. By listening to others ideas, improved management practices and increased technology can contribute to reducing odour emissions.

OD 99-07
An Insect-based Dector of Bovine Manure Odors
Raman, D. Raj, and Reid R. Gerhardt
1997
Proceedings from the 1997 Annual International Meeting, Paper No. 975025, ASAE. 2950 Niles Rd., St Joseph, MI 49085-9659
USA
United States
We designed, constructed, and tested a single-stream insect odormeter for the measurement of bovine manure odors. The bio-sensing element in the odormeter is a group of six gravid face flies (Musca autumnalis DeGeer) in a 360 ml chamber. A microphone, mounted above the chamber, sense the sounds made by the flies' activity. An analog root-mean-square power-measuring circuit connected to a data acquisition system processes the microphone signal. The apparatus allows electronic measurement of insect activity. Initial experiments demonstrate the feasibility of this system for odor detection (yes/no). Kinetic experiments show that injecting a series of increasingly odorous pulses into the system can produce a dose-response curve. As

expected, the repeatability of this technique is dependant on control of biological variables such as the flies' odor exposure history and reproductive state. If face fly responses can be positively correlated with the responses of human panellists, then this technique might enable rapid, reliable and inexpensive quantification of manure odors.

OD 99-08
An On-Farm Swine Waste Treatment System for Odor Control, Byproduct Recovery and Treated Wastewater Refuse in Hawaii
Yang, P.Y., C. Gan, D.G. Paquin and T. Liang
1997
Proceedings from the 1997 Annual International Meeting, Paper No. 975025, ASAE. 2950 Niles Rd., St Joseph, MI 49085-9659 USA
United States
A prototype of a swine waste treatment system for a 240-270 pig operation was investigated for it's potential for odor control, by-product utilization and treated wastewater reuse. It was found that the high solid portion of the swine waste ranging from 4-8% TS could be treated and stabilized by the anaerobic process within HRT of 32 days. Aeration and sedimentation units with HRT of 3 and 4 day could effectively treat the diluted liquid portion from raw and anaerobic ally digested swine wastewater, respectively. The overall removal efficiency of 89-95.4% for TCOD, 82.3-88.5% for TKN and 81.2% for T-P could be achieved. The treated effluent could be used for irrigation of pastures without any negative impact of odor problems. Also, it meets the requirements of the wastewater reuse criteria, R-3 issue by the state of Hawaii, Department of Health. The economic analysis was conducted by calculating the NPW (Net Present Worth). It was found the capital cost is the major cost for the proposed treatment system. The ruse of biogas as energy and sludge as fertilizer is the key factor as to whether or not it will turn the treatment system into a profit. Also, it was found that the operation of approximately more than 830 pigs us required to achieve a break-even point for the application of the swine waste treatment system. Thus, the profit could be made with the application of this treatment system by centralizing the hog operation of the comprehensive utilization of methane gas and stabilized sludge could be proposed.

OD 99-09
A Study on the Air Flow and Odor Emission Rate from a Simplified Open Manure Storage Tank
Liu, Q., D.S. Bundy and S.J. Hoff
1995
Transactions of American Society of Agricultural Engineers. Volt 38(6): 1881-1886
United States
This study presents a numerical evaluation of airflow and odor emission rate from an open manure storage tank. Odour emission rate is needed to facilitate the odor dispersion study and to compare different odor sources in terms of odor emission. The concentration of the manure surface, the tank dimensions, and wind speed were used to calculate airflow and emission rate. The SIMPLIER algorithm developed by Patankar (1980) and two-layer turbulence model were used in numerical simulation with a grid of 152 x 139. The predicted emission rate agreed with the field measurement results found in the literature. Experimental verification of airflow showed that the flow pattern and velocity profile prediction was also in agreement with the experimental results. The calculated emission rate was a function of manure surface areas, the door concentration at the manure surface, the tank dimensions, and the wind speed.

OD 99-10
Relationship Between Concentration and Intensity of Odours for Pig Slurry and Broiler Houses
Misselbrook, T.H., C.R. Clarkson and B.F. Pain
1993
Journal of Agricultural Engineering. 1992, 55, 163-169
UK
Relationships were derived between odour concentration and odour intensity for odour emission following the land spreading of pig slurry and emissions from broiler houses. Data was obtained from trials conducted between 1987 and 1990. Odour concentration measurements were made by 50% threshold determination using a dynamic dilution olfactometer with forced-choice type presentation to a panel of people. Odour intensity measurements were made using the same equipment and required panellists scoring their perception of the intensity of odour at a range of concentrations according to category scale ranging from 0 (no odour) to 6 (extremely strong odours). Intensity was related linearly to the logarithm of concentration. Significant differences (p=0.05) were found between relationships derived for odours from pig slurry and odours from broiler houses. For odours from pig slurry the derived relationship was, Intensity=1.61(log10 concentration) +0.45 and for broiler house odours, Intensity=2.35 (log10 concentration) indicating higher intensity per unit for broiler house odours. These relationships could be useful in estimating the reduction in odour concentration required to reduce the perceived intensity of the odour to acceptable levels and, when used in conjunction with dispersion models, in determining minimum acceptable distances odour source and potential complainants.

OD 99-11
Manure Odor Reduction from Pit Additives
Lorimor, Jeff

Environmental Issues Resource Centre
Odour Management

1996
ISU Extension Publication / Department of Agricultural & Biosystems Engineering, Iowa State University
United States
Odor is a subject of growing public concern. Implementation of an odor control strategy can significantly reduce the level of offensive odor generated from and intensive livestock operation. Commercial pit additives are one alternative in the fight to reduce odor. This study examined the effectiveness of commercial pit additives for odor reduction effectiveness. Odors were tested through olfactometry (A panel of four individual smell mixtures of odorous air from cylinders diluted by specific amounts of fresh air. Dilution rates were adjusted until all panel members detect some odor, the odor threshold. A 0 to 87 percent reduction in the odor threshold was found with various responses to volatile fatty acids, pH, total nitrogen and ammonia nitrogen.

OD 99-13
Evaluating On-Farm Manure Storage Covers for Odor Control
Jacobson, Larry, Charles Radman, Charles Clanton, Kevin Janni, Richard Nicolai and David Schmidt
1997
1996 Annual Report - Research, University of Minnesota, Department of Biosystems and Agricultural Engineering
United States
Air samples were collected from manure storage sites on varying locations throughout Minnesota. Odor was measured using standardized olfactometry, and hydrogen sulfide measured using colormetric tubes. Preliminary data showed varying degrees of effectiveness in eliminating odor for locations studied.

OD 99-14
Evaluation of Experimental Swine Waste Storage Covers for Odor Control
Clanton, C., Kevin Janni, Larry Jacobson, Philip Goodrich, Roger Ruan, David Schmidt and Richard Nicolai
1997
1996 Annual Report - Research, University of Minnesota, Department of Biosystems and Agricultural Engineering
United States
The objective of the research was to evaluate the use of organic and inorganic floating covers to reduce odor emissions from swine waste storage units. Twenty-one 600 litre tanks containing approximately 8% total solids where examined with five potential treatments: no cover, wheat straw (12 in. thick), a 2 cm thick layer of soybean oil, 30 cm straw and oil mat (by placing straw in 4 layers with 1.3 gal of oil between each layer and a Permalon cover.

OD 99-22
Reduction of Odorous Compounds in Fresh Pig Slurry by Dietary Control of Crude Protein
Hobbs, P.J., B.F. Pain, R.M. Kay, and P.A. Lee
1996
Journal of Food, Science and Agriculture. Vol. 71:4, p.508-514. 1996
UK
Two diets containing reduced levels of crude protein for both growing (35-45 kg) and finishing (65-95 kg) pigs were tested against the standard commercial diets to determine changes in odorants produced in fresh slurry. The experimental diets were formulated based on least cost basis using either a full commercial database or with restriction mainly home-grown (UK) cereals and pulses. Major odorants responsible for pig odor from slurries were identified and their concentrations determined using gas chromatography-mass spectrometry. Five out of ten odorants from slurries produced by growing pigs were significantly lower ($P<0.05$) in concentration for each of the low crude protein diets compared with the commercial diet. Reducing dietary nitrogen and providing essential amino acids in an ideal protein ratio not only decreases the nitrogen excreted by the pig, but also reduces the odorants produced in the resultant slurries.

OD98-01
Odour and Ammonia Emission Following the Application of Pig or Cattle Slurry to Land
Pain, B.F., Y.J. Rees and D.R. Lockyer
1988
Volatile Emissions from Livestock Farming and Sewage Operation. Edited by V.C. Nielsen, J.H. Voorburg and P. L'Hermite.
P.2-11
U.K.
Following the application of dairy or swine manure on to grassland, samples of odorous air have been taken
The air temperature during those experiments was relatively low and varied to a range of 0,4 to 1,4 C. The emission evaluation was done during 48h and odour emission stayed high during the first 4 to 5 hours after spreading. The odour rate was higher with the high application rate for this period but later; both application rates produced equivalent emissions.
The experiment was done at low temperature, which may not be representative of all conditions.
A system of small wind tunnels was used to collect samples of odorous air and to measure ammonia emission following the application of pig or dairy cow slurry to grassland. Odour strength of air samples was assessed by dynamic dilution olfactometry and the rate of odour emission expressed as odour units m-2h-1. For both types of slurry, rate of odour emission was high

immediately after application but declined too much lower levels within 4-5 h, and was influenced by wind speed and rate of slurry application. The pattern of ammonia emission was similar to that for odour. Total ammonia loss ranged from 23-76% of the NH4-N in cattle slurry, 80% of the total loss occurring within 2 d of application. Loss of ammonia from pig slurry was directly proportional to rate of application but the rate of emission was much lower than for cattle slurry. Strong correlations were established for odour and ammonia emission for both types of slurry.

ODO 1
Olfaktometrie Geruchsschwellenbestimmung - Olfactometry Odour Threshold Determination - Fundamentals
VDI, Verein Deutscher Ingenieure
1986a
VDI 3881 Part 1. 28 p. VDI - Kommission Reinhaltung der Luft.
Germany
Olfactometry is a method of determination of odorants concentration by presentation of odorants to humans and registration of the resulting sensations; the human sense of smell being used as a detector. This method allows determination of the human smell power for known odorant concentrations and also the determination of unknown odorant concentrations by mean of human smell sense. Guidelines are given for the determination of odour threshold and the derived quantity of odorant concentration. The anatomical/physiological and psycho-physiological fundamentals of the odour phenomenon are presented. The terms used in olfactometry and their definitions are given. The measuring procedures are explained in a general matter covering the instruments, the sampling, the presentation of concentrations, the questioning technique, the panel, and the boundary conditions. The equations for the calculation of odorant concentration are given.

This publication gives a very good definition of the olfactometry and the procedures to realize odour threshold determination. However, the information presented is general and has to be considered as guidelines, not enough details are given to realize standard tests.

ODO 10
Zeolite as feed additive to control swine manure odours and to improve animal growth performance
Barrington, S. and K. El Moueddeb
1995
Paper 95-510. Presentation to the Canadian Society of Agricultural Engineering at the Agricultural Institute of Canada Annual Conference. July 9 - 12 1995. Ottawa, Ontario. 15p.
Canada
Zeolite was used as a feed additive (addition of 5% zeolite) and its effect was verified on swine manure odours and hogs growth performances improvements in an experiment realized on 54 grower hogs. Zeolite is a tektosilicate and was obtained from southern Alberta. This compound is found in volcanic deposits and exhibits a cation retention capacity (CEC) of 400 meq /100g. The group of 54 weaners (average 18.6 kg) was separated equally in two and placed in different rooms, with a control group fed a 16% crude protein pelleted standard feed and the other group fed the same diet supplemented with 5% zeolite. The animals' weight was measured regularly and the given feed was weighed daily. NH3, CO2 and H2S levels were measured regularly in both rooms and manure samples were taken for nitrogen content analysis. The results are given for the first 4 weeks for the hog's performances: the hogs fed the zeolite diet didn't significantly grow at a faster rate but showed a significant improvement in the feed conversion compared to the control group (2.2 kg feed/ kg body weight vs. 2.75 kg/kg). In both rooms, the H2S concentrations were not high enough to be measured. The NH3 levels measured were lower in the room were the zeolite fed hogs were for the 5 first weeks of experiment. This experiment was continued until hogs had reach market weight.

The title suggests that this experiment evaluated the odours to compare the air in the rooms of the hogs fed zeolite supplemented feed and the control group fed standard diet. However, testing were done on only 3 gases and 2 of them being odours components therefore comments can be made on the difference on those gases concentrations but not on the odour. The results presented only the 4 and 5 first week which give and idea on the zeolite possibilities but could not be considered for the whole growing and finishing periods as the hogs' nutritional needs change.

ODO 11
A Review of the Control of Odour Nuisance from Livestock Buildings: Part 1, Influence of the Techniques for Managing Waste within the Building.
O'Neill, D. H. and V. R. Phillips
1991
Journal of Agricultural Engineering Resource (1991) 50, 1-10.
This article makes a review of published information on the impact of waste management practices odour production and emission. After analysis of this information, recommendations are difficult to make regarding specific practices because of the shortage of objective odour measurements but recommendations on research can be done. Different livestock management factors have been analysed and reported such as waste removal, waste decomposition, floor design in the building, treatments done in the building to waste and bedding materials use but interactions between these factors confound the analysis. However the evidence points to frequent waste removal that would prevent anaerobic conditions that occur in the building. This would

lead to odour control as some odorous compounds increase concentrations over 24h period of anaerobic storage conditions. The reduction of moisture content of the waste could apparently limit the anaerobic conditions development. This could explain why odour reduction has been linked to bedding material use. However adequate odour measurement data are needed to conclude on the waste management practices and the use of different bedding materials for odour reduction. Even if ammonia concentration in air and odour strength doesn't show good correlation (not proportional), measures that reduce ammonia concentration in building would also reduce odour and vice versa.

As reported by the authors, the published information is difficult to analyze because the procedures to obtain the results are not standardised and the parameters measured are not always the same as odour strength, odours compounds concentrations, particular chemical compounds are used.

ODO 12
The drive to stifle odor
Leake, L.L.
1996a
Farm Industry News. January 1996. P 112-117.
U.S.A.
As livestock odors are not currently regulated by federal statutes and generally not regulated by state air pollution control agencies, many states and local government units have established regulatory guidelines for new livestock facilities constructions. Guidelines may include information about minimum distances, restricted use of anaerobic lagoons or control of manure disposal areas. More attention should be given to manage the lagoons: recycling the waste material on the land (as fertilizer), making sure the bottom of the lagoon is sealed, limiting the amount of material stored (limiting the water used for waste processing) (from P. Goodrich, professor Univ. of Minnesota). Additives to reduce odor are also discussed by R. Miner (bioresource engineer Oregon State Univ.) and P. Goodrich. Data on manure reduction from additives are not always conclusive and Miner mention that it would be unrealistic to anticipate that even noticeable odor changes obtained from additives to fresh manure or changes in diet would persist during manure decomposition and anaerobic storage. J. Van Horn (dairy scientist at Univ. of Florida) adds that as some additives may reduce the concentration of a specific odorous compound in the manure, but this additive doesn't reduce the overall odor intensity making the product's effectiveness very limited and its use economically uninteresting. Many scientists in Iowa State Univ. North Carolina State Univ. and Univ. of Florida are studying lagoon and feed additives. At North Carolina State Univ. researchers are also studying improved methods to utilize animal wastes and control odor and a project is done to find ways to reducing odor (preliminary findings point trees, barn cleanliness slurry aeration and liquid-solid separation as factors in the odor solution) and determine when odor become a nuisance. Researchers at Purdue Univ. and Penn State Univ. are studying dietary manipulation for odor reduction.

This article contains a lot of information. As some researchers question the ability of additives to control and reduce odor we can see that many teams in different U.S.Univ. are currently working on those additives. Solutions may lay in a combination of different practices to realize significant odor reductions.

ODO 13
Waste Management - Odor Control in Liquid Hog Manure by Added Amendments and Aeration
Al-Kanani, T. (1), E. Akochi (2), A.F. Mackenzie (3), I. Alli (2), and S. Barrington (4).
1992
Journal of Environmental Quality, 21: 704-708 (1992).
Canada
Laboratory studies were done to evaluate the capacity of different amendments and aeration added to liquid hog manure (LHM) to reduce the emission of malodorous gases. The amendments, sphagnum peat moss (80% dry matter) in proportion of 1%, 4% and 8%, monocalcium phosphate monohydrate (reagent grade) (4% addition), H_2SO_4 (1.5 M), H_3PO_4 (1.7M), $CaCO_3$ (2% and 2% + sphagnum peat moss 1%), CaO (2%) and elemental S (4%), were surface applied to manure and mixed by intermittent brief aeration. Aeration and no aeration were also define as treatments for the 1 kg LHM samples placed in 2.7 L jars which incubated for 720 h at 23 C. Gas samples were taken from the jars at 2, 4, 24, 96 and 720 h after the beginning of the experiments and presented to volunteer untrained panellists for sensory evaluation rating the odour presence and offensiveness on a numerical scale of 0 to 10. Gas samples were also taken for gas chromatography and mass spectroscopy analysis. The results showed that aeration markedly reduced the odor. As this process is expensive, considerations should be made on treatments under numerated conditions. The effectiveness of these treatments still have to be evaluated on scale applications however some combination of sphagnum peat moss and $CaCO_3$ should be further investigated in field applications as these are the treatment giving the most interesting results.

Important differences could be obtained in a large-scale application. This experiments leave unanswered questions has to the apparatus necessary to achieve those treatments in a large scale and particularly the economics of such treatments. The method uses to evaluate the odor only qualify the odor intensity and cannot be compared to the olfactometric method more commonly used.

ODO 14
A Study on the Air Flow and Odor Emission Rate from a Simplified Open Manure Storage Tank
Liu, Q. (1), D.S. Bubdy (2) and S.J. Hoff (2)
1995
Transactions of the ASAE. Vol. 38(6): 1881-1886. American Society of Agricultural Engineering.
To represent the odor dispersion with the use of mathematical models, the odor emission rate should be defined, as it is an input parameter of the model. Odor emission rates from open manure tanks are difficult to evaluate and a study was realized to develop a numerical evaluation of airflow and odor emission rate. The tank dimensions, the odor concentration at the manure surface, the manure surface area and the wind speed were input parameters for the mathematical model developed using the SIMPLER algorithm from Patankar and a 2-layer turbulence model to realize numerical simulation with a 152 x 139 grid. Experimental verifications were performed to validate the model for airflow pattern and velocity profile and the emission rate results obtained agreed with field measurements obtained in the literature.

Dispersion models can be effective tool to evaluate the odor dispersion pattern of an odorant source and the area affected. As mentioned, another numerical model was needed to evaluate the odor emission rate of open manure tanks and those odor emissions rate are costly to evaluate with field measurements.

ODO 15
Reduction of Odorous Compounds in Fresh Pig Slurry by Dietary Control of Crude Protein
Hobbs, P.J., B.F. Pain (1), R.M. Kay and P.A. Lee (2)
1996
Journal of the Science of Food and Agriculture. 1996. V. 71(4): 508-514.
U.K.
See the comment of: Control of Odours by Dietary Manipulation, from the same authors in Ammonia and Odour Control from Animal Production Facilities. Proceedings of the International Symposium. Vinkeloord, The Netherlands. October 6-10, 1997. p.267-272.
This experiment was a bit different in the feed composition than newer one but the results are similar in the reduction of odorant compounds.
Two diets containing reduced levels of crude protein for both growing (35-65 kg) and finishing (65-95 kg) pigs were tested against standard commercial diets to determine changes in the odorants produced in fresh slurry. The experimental diets were formulated on a least cost basis using either a full commercial database or with restriction mainly to home-grown (UK) cereals and pulses. Synthetic essential amino acids were included in both formulations to obtain essential amino acids in an ideal protein ratio, with the crude protein being as low as possible. Nitrogen excretion by both growing and finishing pigs offered the low crude protein diets was
significantly lower ($P < 0.001$) than that of pigs offered the commercial diets. Major odorants responsible for pig odour from slurries were identified and their concentrations determined using gas chromatography-mass spectrometry. Five out of 10 odorants from slurries produced by growing pigs were significantly lower ($P < 0.05$) in concentration for each of the low crude protein diets compared with the commercial diet. For the finishing pigs nine out of ten odorants from slurries for the least cost and four odorants for the homegrown diets were significantly lower ($P < 0.05$) than slurry produced from the commercial diet. Reducing dietary nitrogen and providing essential amino acids in an ideal protein ratio not only decreases the nitrogen excreted by the pig, but also reduces odorants produced in the resultant slurries.

ODO 16
Assessment of odours from livestock wastes by a photoionization detector, an electronic nose, and olfactometry and gas chromatography-mass spectrometry.
Hobbs P.J., T.H. Misselbrook and B.F. Pain
1995
Journal of Agricultural Engineering Research. 1995, 60: 2, 137-144
U.K.
The development of equipments that could measure odour concentration is important. This would enable odour emission analysis on sites at a lower cost than olfactometry, which requires odor collection in sampling bags, and sample analysis from a panel. This could also be interesting as some odour compounds are chemically unstable and can change during the analysis delay. However odor evaluation with only equipments is not a technology that can be used right now, as more research has to be done to improve.
A photoionization detector (PID) and an electronic nose (EN) based on polypyrrole sensors were evaluated against odour concentration measurement by olfactometry using odours from pig and chicken slurry. Olfactometry was more sensitive than the PID and EN which gave responses down to 1000 and 60 000 Odour Units m-3 in air, respectively. Although the PID was more sensitive, the EN was better at discriminating between different odours through the pattern of sensor responses. Differences in chemical composition between pig and chicken odour were analysed using gas chromatography-mass spectrometry (GC-MS). Different chemical profiles were obtained for odorous compounds extracted from slurries by organic solvent and purging with air. Some of the major odour compounds were chemically unstable, so rapid, portable devices for

odour measurement may have considerable advantages.

ODO 17
Continuous farm scale aeration plant for reducing offensive odours from piggery slurry: control and optimization of the process.
Burton, C.H. and R.W. Sneath
1995
Journal of Agricultural Engineering Research. 1995, 60: 4, 271-279
U.K.
More work has to be done in order to control and evaluate the variability in the raw manure that has to be treated. Optimization of the aeration process could lead to lower operation costs.
Optimization of a continuous aeration process for pig slurry by varying the treatment time to reflect the solids content of the feed is described. The target quality of the treated slurry was to withstand 25 d of storage before returning offensive odours (indicated by a total VFA concentration exceeding 0.23 kg/m3). Correlations developed in earlier studies were used to link the solids content of the raw slurry to its chemical oxygen demand (COD) value and to the length of treatment required. Methods for direct measurement of solids content were found to be both expensive and unreliable, leading to the development of a method based on the relationship of separator performance to the total solids concentration of the raw slurry. Using this information, the treatment time was periodically revised to reflect changes in the feed slurry, ensuring that the target quality was maintained. The viability of this strategy was tested by a continuous computer-controlled trial lasting 22 d. Measurements of the VFA concentration of treated samples after 25 d storage indicated that control was working. Potential savings from the optimization strategy will depend on the variability of the raw slurry concentration. On the basis that all slurry treated should meet the 25-d storage criterion, a fixed treatment time would need to be set to treat the thickest slurry expected. For the trial carried out, this fixed treatment time would have been 4 d. However, with the control system in operation, treatment lasting 2 d sufficed for half of the trial period. The saving in cost implied for this case is around 25%.

ODO 18
A farm scale study on the use of De-Odorase for reducing odour and ammonia emissions from intensive fattening piggeries.
Amon, M., M. Dobeic, T.H. Misselbrook, B.F. Pain, V.R. Phillips and R.W. Sneath
1995
Bioresource Technology (United Kingdom), 1995. v. 51 (2/3), p. 163-169
Slovenia, UK
The methodology used for this experiment is very interesting and efficient for farm scale testing of additives. The availability of many building made repetition possible which improve greatly the results validity with statistical analysis. De-Odorase can reduce ammonia concentration and emission (considering the ventilation rates) by 26% however no significant odour concentration and emission reduction could be measured.
An experiment was mounted at a large fattening piggery in Slovenia, during which different groups each of 600 weaned pigs were housed and grown in different fattening rooms for 60 days (from age 24 days to age 84 days). All rooms were mechanically ventilated and had fully slatted floors with slurry channels beneath. De-Odorase was added to the diet of the treated groups of pigs at the rates recommended by the suppliers, e.g. for grower feed, 65 g/t. De-Odorases was also added daily (32 g suspended in 10 l of water) to the upstream ends of the slurry channels. Once a week, the ammonia concentration in the air inside each fattening room was measured at each of four positions, using Drager tubes, and the ventilation rate was computed from the cross-sectional area of each fan outlet and the average velocity of the air emerging from each. Also, air samples were taken from immediately outside three of the fans serving each room, and their odour concentrations were measured by olfactometry. Hence, weekly values of emission rates of both ammonia and odour could be calculated. Ammonia concentration was significantly lower ($P = 0.001$) in the De-Odorase-treated buildings than in the control buildings. The average reduction in ammonia concentration over a 7-week period was 26%. Ammonia emission rate was also reduced by 26% through the use of the additive. This reduction was significant at $P = 0.048$. Neither odour concentration nor odour emission rate was significantly reduced through the use of the additive. The additive did not significantly influence the rate of live-weight gain by the pigs.

ODO 19
Dispersion of Odours From Ground Level Agricultural Sources
Smith, R.J.
1993
Journal of Agricultural Engineering Research. 1993, 54: 187-200
Australia
Most dispersion models have originally been developed to describe odour dispersion pattern from industrial source pollutants. In agriculture, most of the odour sources are at or near ground level, there is generally no plume rise developing, the source may differ a lot from point-source and be of large aerial extent, the emission source may be relatively close to the receptor zone, the odour emission rate is difficult to measure (not a single pollutant component), the emission rates can vary in time and space and finally the emissions can be of relatively low intensity. Adaptations have to be done to the model currently used to take into account these agricultural factors.
The problem of predicting the dispersion of odours from aerial sources such as cattle feedlots or waste disposal areas is

addressed. A model for predicting the odour concentration from these sources was developed, the main features of which are an improved representation of the source and an ability to accommodate a non-axial wind direction. It was demonstrated that the methods used previously underestimate concentrations close to the source. The sensitivity of the concentration predictions to variation in the model parameters was assessed. The wind speed and odour emission rate were found to be the most important variables in the prediction of downwind concentration. Other parameters of importance are the atmospheric stability and the roughness height of the ground surface.

ODO 2
Olfaktometrie Geruchsschwellenbestimmung - Olfactometry Odour Threshold Determination - Sampling
VDI, Verein Deutscher Ingenieure
1987
VDI 3881 Part 2. 10 p. VDI - Kommission Reinhaltung der Luft.
Germany
Guidelines are given for the sampling procedure for odour measurements with an olfactometer considering two sampling methods: the dynamic sampling where partial flow of the sample is continuously taken from the source and directly used to supply the olfactometer on demand and the static sampling where odorous samples are collected in vessels which are later connected to the olfactometer. General considerations are given regarding the sampling such as the possible condensation in the vessel or the instruments used, the interaction with the sample and the condensation surface and reactions among the odorants involved. The dynamic sampling and the static sampling methods are presented with figures showing the basic apparatus. Dynamic odour measurements are recommended for emission source that present stable period of odour concentration emissions, at least during the course of a single measurement. This method also presents advantages because of the short time elapsing between the sampling and the analysis; less chemical reactions in the sample can occur.

The sampling procedures are well presented and explained but not enough specific information is given for the apparatus. This could lead to differences between samplings done over long periods of time and also sampling and analysis done by different laboratory which could use the same sampling methods but no the same apparatus. References to VDI 3881 Part 1.

ODO 20
A Review of the Control of Odour Nuisance from Livestock Buildings: Part 2, The Costs of Odour Abatement Systems as Predicted from Ventilation Requirements
O'Neill, D.H. (1), I.W. Stewart (2) and V.R. Phillips (1)
1992
Journal of Agricultural Engineering Research. 51, 157-165.
U.K.
English pound (L).
The costs of odour abatement systems to reduce odour nuisance from livestock buildings were predicted from the max. Ventilation requirements of the buildings. Twelve odour abatement systems were considered, but only those which were judged to be effective (7) were coasted. The 7 effective systems include chemical or biological treatments of air leaving the building, or natural dilution of odorants in the atmosphere. Since these methods depend on forced ventilation within a building, the costs include installation of both ventilation equipment and treatment plant to meet the max. Requirements for typical buildings. The analysis was undertaken to provide cost predictions and to allow them to be compared. Chemical treatments were found to be prohibitively expensive. Biological treatments and chimneys, although much cheaper, still carried a large overhead per animal. The cheapest treatment in terms of both capital and annual costs was a biofilter (œ8 per pig or œ0.18 per broiler in the examples considered). For the biofilter, capital and annual costs per unit of ventilation demand were L0.52/(m3h-1) and, resp. L0.14/(m3h-1).

ODO 21
Controlling Swine Manure Odors Using Artificial Floating Scums
Meyer, D.J. (1) and J.C. Converse (2)
1982
Transaction of ASAE. 25: 1691-1695, 1700.
U.S.A
The odor level evaluation was done by the panel members going directly over the barrel to evaluate the offensiveness of each treatment compared to the reference (strongest smelling barrel) on a scale from 10 to 70 (being the strongest smell). This method is based on comparison to the control and the odor level measured cannot be compared to results from other experiments. Permeability tests of the covers were done to measure H2S and ammonia off-gases. Considering the durability test, the odor panel test and the gas permeability test, rice hulls with waste oil and grass with waste oil where the most effective floating materials. However the use of waste oil mixed with other material may not be an environmentally sound way of controlling odor as waste oil can be considered hazardous waste.

ODO 22
The Effect of Environmental Odors Emanating from Commercial Swine Operations on the Mood of Nearby Residents

Schiffman, S.S., E.A. Sattely Miller, M.S. Suggs and B.G. Graham
1995
Brain Research Bulletin. Vol 37, No. 4, pp. 369-375.
U.S.A.
The Profile of Mood States (POMS) was used to determine the effect of environmental odors caused by intensive hogs operations on the mood of nearby residents. 44 experimental subjects rated their mood using a POMS questionnaire and their rating of six POMS factors and the total mood disturbance (TMD) was compared to the ones of 44 control subjects. Gender, race, age and years of education were considered in order to have control and experimental subjects that could be compared. The results showed that when comparing the six POMS factors and the TMD, statistically significant differences were obtained between the experimental group and the control. Consulting the POMS questionnaire the results showed that the persons leaving closer to the swine facilities experienced the odors reported more tension, more depression, more anger, more confusion, more fatigue and less vigour than the control subjects. The treatment group also reported mood disturbances more frequently. The mood impairment reported could be partly explained by both innate physiological responses and learned responses.
The effects of odors on nearby residents of commercial swine operations are presented following a study on profile of mood states. It is important to better understand the human reactions to odors and also to evaluate and verify the consequence of odors exposure on health and well being of swine operations neighbours. Odor thresholds associated with the reactions could be helping define zoning or odor abatement systems for specific situations.

ODO 23
Anglo-Dutch experiments on odour and ammonia emissions following the spreading of piggery wastes on arable land.
Pain, B.F., V.R. Phillips, J.F.M. Huijsmans and J.V. Klarenbeek
1991
Rapport 91-9, December 1991, prijs f 25, -. IMAG-DLO, IGER and Silsoe Institute. Dienst Landbouwkundig Onderzoek. Instituut voor Mechanisatie, Arbeid en Gebouwen. 28 pp.
U.K. and The Netherlands
Experiments were done with researchers from the Netherlands and UK to evaluate odour and ammonia emissions (OAE) following spreading of pig slurry on arable land. Emphasis of the Netherlands team was directed toward ammonia reduction where the UK team paid more attention to odours. Tilling is a good way to abate OAE as the slurry surface exposed to air is greatly reduced furthermore the contact of the ammonium with soil colloids is increase thus reducing ammonia emissions. Investigations were done with manure application on clay soils and also in sandy soils and different tillage techniques (plough, rotary harrow and tines) were tested for their abilities in OAE control. Various manure management techniques were also tested for ammonia emissions (solid-liquid separation, pit storage under slatted floor for the entire fattening period and weekly manure removal and storage in enclosed tank).
The results showed that any delay of incorporation results in higher total OAE; the longer the delay, the more OAE. Incorporation by ploughing gave better results in clay soils; as for sandy soils both ploughing and rotavating were interesting. The cultivator technique was the least effective one on clay and sandy soils.
However for odours, only substantial reductions were noted for direct incorporation on clay soil and delaying incorporation did not affect the emission level significantly. Significant differences were obtained with different machinery and ploughing showed to be the most effective for odour abatement. For the manure management techniques, no substantial difference in ammonia emission were measured between when the manure was removed weekly compare with the manure being stored for the whole fattening period. The separation technique showed to be more effective in reducing ammonia emissions after landspreading, as the losses from urine were less than 20% compared to slurry (control) and the losses from the faeces where equivalent to the one of the control.

This work is interesting and combined the expertise from researchers from 2 European countries that had mostly different concerns, ammonia emissions for the Netherlands and odours for the UK and different expertise, the UK gained expertise in olfactometry and measurement of emissions during spreading and the team from the Netherlands benefited from the micrometeorological and wind tunnels method used by the AFRC-IGER team

ODO 24
Controlling Odors from Livestock Production Facilities: State-Of-The-Art
Miner, J.R.
1981a
Livestock Waste: a Renewable Resource. Proceedings of an International Symposium. American Society of Agricultural Engineering. 297-301
U.S.A.
This publication gives a broad review of the odor situation as it is in 1981. General information is given on the physiological reactions associated to odor and the complexity of odor is also presented. A list of odorous volatile compounds is given and information about ammonia releases associated to specific practices is also given. Odor measurements are also discussed, presenting olfactometry and also the cotton swatches technique and mentioning that the concentration of certain odor

components cannot be considered as odor indicator. The group of odor sources such as feed material, fresh manure, and stored or decomposing manure are to be considered. Odor control principles and approaches are presented being pH control to limit ammonia releases, inhibition of anaerobic decomposition (aeration, usage of bedding, oxidation ditches and aerated lagoons), physical confinement of manure (covered manure storage, anaerobic treatment devices) and finally reduction of exhaust air odor (by air-borne particles removal). The odor control can be done also by the addition of odor control chemicals added to feed or manure. Management practices and different designs can be done to control odor such as proper siting with a proper perimeter separating the livestock production unit and manure storage facilities from the neighbours, consideration in the siting to prevalent wind direction, proper management control to keep the animals clean and frequent manure scraping or flushing and to maintain good storage conditions. A good timing (to avoid nuisances and interference with recreational activities) and techniques (injection, plough right after spreading) for manure disposal are also essential in order to limit complaints from neighbours.

This is a good review of for the time. Many considerations in 1981 are still accurate in 1997 and many questions raised are yet not answered.

ODO 25
Controlling Odors from Livestock Production Facilities
Miner, J.R.
1981b
Research Results in Manure, Digestion, Runoff, Refeeding, odours. North Central Regional Research Publication No. 284. 30-35
U.S.A.
See the summary of: Controlling Odors from Livestock Production Facilities: State-Of-The-Art. 1981. Miner, J.R.

ODO 26
Management of Odors Associated with Livestock Production
Miner, J.R.
1975
Managing Livestock Wastes. ASAE PROC-27S
U.S.A.
See the summary of: Controlling Odors from Livestock Production Facilities: State-Of-The-Art. 1981. Miner, J.R. But this publication doesn't cover the management practices and design to control odors.

ODO 27
Biological Removal of VFA from Animal Wastes (Volatil Fatty Acids)
Tanaka, H., K. Kuroda, and M. Yanaga
1992
Animal Science and Technology. (Jpn.). 63 (1): 54-59
Japan
The use of a bioscrubber and compost as treatment for VFA on a laboratory scale has been very effective. However even if the VFA play an important role in odour emissions, no information has been given on the possible odour reduction.
Biological removal of volatile fatty acids (VFA) from swine faeces was investigated, using a bioscrubber with activated sludge. The results were compared with treatment using a compost product with respect to odour removal. The bioscrubber was packed with honeycomb tubes to remove aerial VFA. The scrubbing fluid contained activated sludge. Both processes resulted in a reduction in odours almost below the limits of detection. The remarkable deodorization produced by the compost product was attributed to adsorption and neutralization followed by microbial degradation.

ODO 28
The Use of Dried Bacteria Cultures and Enzymes to Control Odor and Liquefy Organic Waste Found in Hog, Dairy and Poultry Producing Units as Well as Lagoons
Bergdoll, J.F.
1975
Managing Livestock Wastes. ASAE Proc-27S: 372-373
U.S.A.
Big Dutchman Improved Odor Control has been tested in four separate tests to evaluate the capacity of the product in reducing odours and liquefying the organic waste fund in the slurry. Visible changes in the manure could be observed and analysis done showed that the product would bring liquefaction of hog manure.

No real analysis is done on the odour at the exception probably of a qualitative evaluation for which no results are presented. This test was done only in two swine buildings, a treated one and a non-treated one, the control. This is not sufficient to be able to draw conclusion.

ODO 29

Methods for Evaluating Odor from Swine Manure
Riskowski, G.L., A.C. Chang, M.P. Steinberg and D.L. Day
1991
Applied Engineering in Agriculture. 7 (2): 248-253
U.S.A.
A good review of the odour evaluation methods is given. The magnitude method and the ranking methods were used to evaluate manure aeration and additive addition at different rates. The panel members in the first case had to give a magnitude estimation of the odour using a scale from 1 to 9 with the distilled water being assigned 1 on the scale and untreated manure being 7 on the scale. Toward the end of the testing, ranking evaluation was also done comparing only 2 samples and deciding which on is the more offensive. The ranking method appeared to be the more precise method than magnitude however ranking doesn't give any information on the differences noticed.
Two odour evaluation methods were tested during a 12 wk dynamic experiment on the effects of a commercial additive on pig manure in anaerobic storage. One method was a rating method which combined many of the best features of past research methods. The other method was a ranking method, which was designed to limit the effects of odour fatigue. Manure was collected daily from growing-finishing pigs and added to barrels at a rate corresponding to the vol. of manure that would fall on the barrel area in a typical pig pit. Odours were analysed weekly by human sniffers and detector tubes were used to measure ammonia, amines and hydrogen sulphide. The manure was also analysed for total solids content. Results showed that the magnitude estimation rating method could distinguish between odour levels when there was a significant difference in odour levels. The ranking method distinguished a difference between the highest treatment level and untreated manure which may indicate that it is a more precise method but was of limited use on its own because it did not give the magnitude of the difference.

ODO 3
Olfaktometrie Geruchsschwellenbestimmung - Olfactometry Odour Threshold Determination - Olfactometers with gas jet dilution
VDI, Verein Deutscher Ingenieure
1986b
VDI 3881 Part 3. 10 p. VDI - Kommission Reinhaltung der Luft.
Germany
Guidelines are given for the use of olfactometers for dynamic dilution. The olfactometer uses a gas jet pump, which thoroughly mixes the metered odorous flow and the constant neutral airflow. The mix is presented as concentration step for odour to panellist through a nose mask for evaluation. The threshold evaluation requires yes/no decision confirming the detection of odours. Two instruments are presented (Olfactometers Model 1158 and TO 4) with their apparatus diagram representing the components and the air and odour flows. For the first model 1158, an operator does all the procedures so the panellists only have to test the mixed samples. For the TO 4, which is a portable measuring device, the panellist is also the operator. Panellist's selection has to be done in order to make sure that the persons' sense of smell is normal and that they can follow the operator's instructions. External disturbance should be avoided when the panellists are making the measurements as odours, noise, vibrations can affect the concentration and the odour sensation. Also verifications should be made to assure that the air mix reaching the nose mask does not contain toxic gases. The dilution system should be calibrated prior to the first use and at least annually using suitable test gases (propane or n-butane in test gas bottles) and gas analyzers. Measuring procedures are also provided. The instruments presented can be used in odour intensity determination and to determine the hedonic tone of an odour. A minimum dilution concentration has to be considered for each instrument considering their technical limits. For the instruments presented, determination of odorant concentration below 15 OU/m3 should not be allowed.

Detailed information is given for the dynamic dilution tests. However, this information is not precise enough regarding the apparatus and technical specifications. References to VDI 3881 Part 1 and 2.

ODO 30
Odor Control of Liquid Dairy and Swine Manure Using Chemical and Biological Treatments
Cole, C.A., H.D. Bartlett, D.H. Buckner and D.E. Younkin.
1975
Managing Livestock Wastes. ASAE Proc-27S: 374-377
U.S.A.
The short-term control experiments showed effective odour and sulfide reduction from the treatment of swine manure with hydrogen peroxide, sodium hypochlorite, chlorine dioxide and potassium permanganate dosed at 500 ppm. The most cost effective one being hydrogen peroxide. Long-term control experiments done with dried enzymes, dried bacteria and orthodichlorobenzene did not reduce the odour or the sulfide.

The rating technique was used in this experiment to evaluate the odour changes with the treatment.

ODO 31
Evaluation of Commercial Manure Additives to Control Odors from Swine Barns
Nicolai, R.E. (1), J. Johnson (2) and R.L. Mensch (3)

1997b
Paper 974041. 1997 ASAE Annual International Meeting. August 10-14, 1997. ASAE, 2950, Niles Road, St.Joseph, MI 49085-9659.
U.S.A.
The protocol is presented and some analysis results are shown to validate this protocol. Only two buildings are compared, one treated and one that hasn't been treated. The validity of the results would be increased if more than one building was used to test each additive.
A protocol was developed and tested to evaluate commercial manure additives in pig finishing barns. The ammonia and manure were analysed for fertilizer value. Air samples, collected at regular intervals in a consistent manner, were analysed for odour threshold with a triangular force choice olfactometer. This approach allows a direct comparison of treated and untreated facilities to be made simultaneously under the conditions in which the additives would be used.

ODO 32
Odor Control Additives: Protocol for Evaluation
Williams, C.M.
1995
Proceeding Wastes Symposium. University of Florida. March 21-22, 1995. p. 36-43
U.S.A.
A review of on odour and the nature of additives are done and the protocol used in the Animal and Poultry Waste Management Centre of NCSU is presented. This protocol is to be done in laboratory and use the cotton cloth for odour capture.
As discussed the cotton cloth technique for odour capture is not reliable for odour evaluation.

ODO 33
Olfactometry Measurement of Animal Manure Odor
Sobel, A.T.
1972
Transactions of the ASAE. 1972 p. 696-699 - 703
U.S.A
Olfactometry measurements were done using a scale from 0 to 10 to rate the odour on offensiveness (quality and strength) and presence (intensity or strength). Olfactometry tests were done directly on manure samples and control samples that were not visible to the panel members. The results showed that the rating method provides valuable information for comparing manure handling and treatment systems. The results should be used for comparison only.

This provides interesting information on olfactometry at its beginning.

ODO 34
Examining the performance of additives in reducing the odor and ammonia emissions from slurry with a standard test procedure.
Buscher, W. (1), E. Hartung (2), T. Jungbluth (2)
1997
Paper 974121. 1997 ASAE Annual International Meeting. August 10-14, 1997. ASAE, 2950, Niles Road, St.Joseph, MI 49085-9659. 7p.
Germany
The protocol presented is dedicated to evaluation of additives in laboratory using a heated water-bath where the manure samples put in glass containers are placed. Air samples are extracted from that container for olfactometry evaluation and analysis for ammonia. The costs of common slurry additives is presented as ranging from 10 to 60 DM (6 to 35 US$) per livestock unit (500 kg live weight) per year. Ammonia reduction of 46%, 53% and 64% was obtained with rapeseed oil mix to the manure to form a top layer for addition of 20, 40 and 60 l of oil /m3 of manure.

No links are made between the results of those tests done under controlled conditions and what can happen in real scale situation.
A test procedure was developed to quantify the effectiveness of additives, which reduce the release of ammonia and odour from slurry. The procedure was tested after technical and statistical optimization with an examination of 4 additives. The results support the implementation of this method with algae extract being the most effective, reducing cattle and pig slurry by 11 and 14% respectively. Results of the influence of thickness of a rapeseed oil layer on the surface of the slurry for ammonia and odour emission reduction are also presented and show the thickest layer (60 litres/m2) to be most effective, reducing ammonia and odour emissions by 64 and 78% respectively. This test procedure is to be developed into an open standard, and will be applied in the departments of Agricultural Engineering in Hohenheim and Halle, Germany.

ODO 35
Design, Construction, and Validation of a Pilot-Scale Biofiltration System for the Reduction of Swine Odor
Young, J.S. (1), J.J. Classen (2), R.W. Bottcher (2) and P.W. Westerman (2)

1997a
Paper 974039. 1997 ASAE Annual International Meeting. August 10-14, 1997. ASAE, 2950, Niles Road, St.Joseph, MI 49085-9659.
U.S.A
Cotton swatch method was used to compare the odours before and after the biofilters. No information is given on the possibility of making those biofilters on a scale size to test it on swine facilities.
Three pilot-scale biofilters and necessary peripheral equipment were built to clean odorous air from the pit of a pig gestation building at North Carolina State University, USA. A computer measured temperatures, flow rates, and pressure drops, and also controlled and measured the moisture content of a biofilter medium comprised of a 3:1 mixture of yard waste compost to wood chips mixture (by volume). The average odour reductions measured by odour intensity, irritation intensity, and unpleasantness for 5 tests was 61%, 58%, and 84% respectively. No significant differences in odour characteristics of outlet air were found among the biofilters.

ODO 36
Development of a Low Cost Biofilter for Swine Production Facilities
Nicolai, R.E.and K.A. Janni
1997
Paper 974040. 1997 ASAE Annual International Meeting. August 10-14, 1997. ASAE, 2950, Niles Road, St.Joseph, MI 49085-9659. 8p.
U.S.A
This type of biofilter is very interesting, simple, effective and economical (0,28 US$ per piglet produced for construction and operation costs considering a facility of 700 sow that produces weaned piglets). More design and operation information is needed and further research will try to determine:
- the relationship of the pressure differential vs. the air flow for various depths and biofilter material;
- the minimum exhaust air contact time to the filter medium required to obtain adequate odor reduction for various livestock species;
- practical dust removal techniques for the exhaust air to prevent biofilter clogging;
- practical moisture application system for the biofilter and the proper management of this system to apply and control moisture in the filter bed.

See Zeisig and Munchen, 1988
An experimental biofilter was built to treat exhaust air from a continuously running minimum ventilating fan that withdrew air from the manure pit under a farrowing barn. The low cost biofilter was constructed out of wooden poles laid on the ground and perforated plastic slats covered with a mixture of compost and kidney bean straw. Biofilter performance was monitored for 9 months by measuring temperature, pressure drop, odour threshold, hydrogen sulfide and ammonia concentrations. A sprinkler system was added to add moisture during mild and warm weather. Average odour and hydrogen sulfide removal was between 75 and 90%. The cost of a proposed system for a breeding, gestation, and farrowing facility is estimated to be $0.28 per piglet.

ODO 37
Evaluating the Toast R Aerobic System for Odor Control
Goodrich, P.R. (1) and J.L. Petering (2)
1997
Paper 974037. 1997 ASAE Annual International Meeting. August 10-14, 1997. ASAE, 2950, Niles Road, St.Joseph, MI 49085-9659. 9p.
U.S.A
In this experiment it would have been interesting to have information about the ammonia emissions and that information is not given. The comparison is made between to barn only and unfortunately no information is given on the cost of such system.
A novel aerobic animal waste treatment system (Tertiary Oxygen Activated Sludge Treatment - TOAST R) was constructed on an operational pig farm in southern Minnesota, USA. The fully operational system was evaluated for odour reduction impact by comparing the treated barn with an adjacent barn operated in anaerobic mode. The reduction in odour in the treatment barn compared with the odour in the control barns was significant. For most tests the odour units in the control barn were double those in treated barn. The odour units measured on the untreated manure were twice those on the treated manure. Hydrogen sulfide emissions were more from the untreated manure. The method of evaluating odour used an olfactometer with sensory panels to judge air samples.

ODO 38
Development of a Dynamic Olfactometer Lab
Nicolai, R.E., C.J. Clanton, P.R.Goodrich, L.D. Jacobson, K.A. Janni, V.J. Johnson, E.Lees and D.R. Schmidt
1997c
Paper 974019. 1997 ASAE Annual International Meeting. August 10-14, 1997. ASAE, 2950, Niles Road, St.Joseph, MI 49085-9659.
U.S.A

Quite interesting information are given on olfactometry, the apparatus, the panel selection and training, the sampling procedures and the evaluation of those samples.
Odour measurement is a requirement for science-based improvement in controlling odour emissions from livestock facilities. The Biosystems and Agricultural Engineering Department at the University of Minnesota developed an olfactometer laboratory to measure odour threshold and intensity. Laboratory layout and odour panellist selection and training are important for obtaining reliable results. Procedures in the new lab are described.

ODO 39
Reduction of Ammonia and Odor Emissions from a Piggery with Biofilters
Hartung, E., T. Jungbluth and W. Buscher
1997
Paper 974126. 1997 ASAE Annual International Meeting. August 10-14, 1997. ASAE, 2950, Niles Road, St.Joseph, MI 49085-9659.
Germany
This work is very interesting because the follow up has bee done on biofilter that have been operating in Germany for many years. The efficiency in odour reduction is very interesting.
Long-term measurements were carried out in parallel on 2 biofilters under practical conditions to test their ammonia and odour emission reduction potentials. The average efficiency of the ammonia reduction calculated for the entire first measuring period (using 6.5 year old filter material) was approx.15% for biofilter 1 and 36% for biofilter 2. The average efficiency of odour reduction calculated for the entire first measuring period was approx.78% for biofilter 1 and 80% for biofilter 2. Ammonia reduction efficiency was mainly influenced by the airflow rate. Odour reduction was mainly influenced by odour concentration before entering the biofilter. The cleaning efficiency of ammonia could be improved by increasing the moisture content of the biofilter material from 20 to 40% and further still from 40 to 50%.

ODO 4
Olfaktometrie - Bestimmung der Geruchsintensitat - Olfactometry - Determination of Odour Intensity
VDI, Verein Deutscher Ingenieure
1992
VDI 3882 Part 1. 27 p. Kommission Reinhaltung der Luft im VDI und DIN.
Germany
This guideline was developed to describe an olfactometric method to investigate odorant samples whose concentrations are above the odour threshold (suprathreshold) and relate them to sensation intensity induced in human. While evaluating many samples whose concentrations vary and exceed odour threshold, intensity variation can be assess. The use of olfactometers and this method allow the evaluation of degree of odorant concentration reduction that could be obtained from different emission treatments or from dilution (such as samplings taken at different distances from the source). Information is given on the procedures that have to be done to realize the tests (sampling procedures from VDI3881, panel selection of at least 8 persons, olfactometer, presentation of the different odorant concentrations, exposure and response to stimuli associated with an intensity level scale from 0 - not perceptible to 6 - extremely strong). The evaluation of the results is also explained with the presentation of the test results, the mathematical evaluation and the graphical presentation to clearly represent the intensity variations of a specific odorant gases or air mixes at their different concentrations. A relationship is established between the odorant concentration and the odour intensity thus giving the suprathreshold intensity variation. However to establish nuisance, the hedonic odour response, the frequency and exposure time have also to be considered.

This guideline is interesting and gives the frame for odour intensity determination. However, the information given is general and the results obtained could be difficult to reproduce (different laboratory with different apparatus).

ODO 41
Odor Emission from Traditional and Low-emitting Swine Housing Systems: Emission Levels and their Accuracy
Ogink, N.W.M., C. ter Breek and J.V. Klarenbeek
1997
Paper 974036. 1997 ASAE Annual International Meeting. August 10-14, 1997. ASAE, 2950, Niles Road, St.Joseph, MI 49085-9659. 6p.
The Netherlands
The content of this publication is relatively similar to the following:
Evaluation of a Standard Sampling Method for Determination of Odour Emission from Animal Housing Systems and Calibration of the Dutch Pig Odour Unit into Standardized Odour Units.1997. Ogink, N.W.M. and J.V. Klarenbeek.
See the comments given.
The introduction in the Netherlands of new housing systems with low ammonia emission created a demand for the evaluation of their odour emission. A 3-year measurement program was started to investigate odour emission from both traditional and low-emitting systems. Measurements are carried out according to a new odour measurement protocol for livestock operations. The first part of the program involves research into the accuracy of the protocol for 2 pig-housing systems. Sources of variation are quantified and sampling schemes are discussed in relation to accuracy.

ODO 42
Fabric Swatches as an Aid in Livestock Odor Evaluations
Miner, J.R. and L.A. Licht
1981
Livestock Waste: a Renewable Resource. Proceedings of an International Symposium. American Society of Agricultural Engineering. 302-305
U.S.A.
The cotton fabric swatches technique is presented as an alternate means to detect odor differences. The technique is simple and requires little equipment and has proved to be satisfactory.

This technique has proven to be ineffective in the determination of odor levels when the odor concentration is moderate to high. See: Livestock Odor Measurement using a Venturi Olfactometer and Odor Sampling using Cloth Swatches. 1997. Nicolai, R.E., L.D. Jacobson, D.R. Schmidt and C. McGinley.

ODO 43
Odorous Compounds from Treated Pig Manure
Yu, J.C. (1), C.E. Isaac, R.N. Coleman (2), J.J.R. Feddes (1) and B.S. West (3)
1991
Canadian Agricultural Engineering. 33(1): 131-136.
Canada
This experiment has been verifying the evolution of different odorous compounds under the treatments. Conclusion is made on odour changes however no direct measures on the odour have been done. Conclusion on the odour cannot be made, only on the variation of certain compounds.
Three pig slurry treatments were evaluated for their effectiveness in the reduction of odorous compounds associated with stored slurry. These treatments included oligolysis (an electrolytic process), Bio-gestTM and Nature-aidTM (proprietary odour reducing agents). In addition, a control was included as a reference to the 3 treatments. Manure was stored in 205 litre bioreactors for an 8-wk period. Volatile organic acids were found to be higher and ammonia levels lower in the liquid phase of the Bio-gest and Nature-aid treatments than in the oligolysis and control treatments. Little difference between the measured parameters (with the exception of propionic acid) was observed between the control and oligolysis treatment. Volatile organic acids, and phenolics and H2S were measured in the gas phase. The gas generated from the oligolysis treatment contained 94% less H2S than gas from the other treatments and odour was reduced. There were no statistical differences between the treatments for volatile organic acids and phenolics for the gas phase of treated pig manure.

ODO 44
Final Report. "Evaluation of Commercial Manure Additives"
AURI, Agricultural Utilization Research Institute
1997
Agricultural Utilization Research Institute. Jack Johnson, P.O. Box 251, Waseca, MN 56093
U.S.A
8 additives (Bio Charge, Roebic Deod. Pit Boss, Shac, BIO-409, MS-4, Pit Shop', Deo Odorase) have been tested during a nine month period on commercial scale in 8 farms in order to determine the impact of such additives on odour and ammonia reductions. Each of the 8 farms was paired with another identical production facility where no additive was used to be able to estimate the reduction obtained. A sampling procedure has been developed. Air sampling was realized in each building and olfactometry tests with a panel were performed within 24 hours. Ammonia and manure (analysis done: pH, total nitrogen, ammonia nitrogen, phosphorus and potassium) samplings were also realized. Pit Additive Reports give information on the testing site, the product application procedure, the product cost and the results obtained. For all 8 products tested, the cost of manure treatment was less than 0,95 CAN$ per hog produced. The results show a wide variability in the results for each product and also between the different farms used as control.
Products are difficult to compare between them, as the testing sites were different, resulting in different conditions. The odour level and ammonia concentration were very variable between the control farm so an important odour reduction (in percentage) in a farm that had high odour emissions could be less important in another farm where odor were less of a problem (du to building design or management). No repetition of the testing has been done. Considering all these elements, this experiment doesn't help in choosing one product over another.

ODO 46
Options for Managing Odor.
Swine Odor Task Force.
1995
Published by the North Carolina Agricultural Research Service, North Carolina State University. Electronic document: www.ces.ncsu.edu/whpaper/SwineOdor.html. 45 p. Consulted on 10/14/1997.
U.S.A
In 1993 after the North Carolina General Assembly and the North Carolina State University recognized that swine odor

problems had to be address in a specific way, the Swine Odor Task Force was formed. Two broad questions were to be answered and they are: "What are the primary sources and causes of odors from swine operations? How can those odors be reduced or make less offensive?" The swine production has doubled in North Carolina in the last four years with no real adjustment to environmental considerations and manure management and also increasing contacts between non-farming rural residents and farms. In many communities, odor complaints started making the news. The answer on the questions is presented in this report and information about the industry growth, public conflicts, odors, waste management, and water quality are presented. Options for odor reduction are also presented for now and for the future. The main avenues toward odor reduction are related to overall better management thorough out the production.

This document covers well the situation of odour and the information is presented in order to be understood by a broad group of reader. However it is not possible to refer to the information sources used in order to write this report, as the references are not given.

ODO 5
Olfaktometrie - Bestimmung der hedonichen Geruchswirkung - Olfactometry - Determination of Hedonic Odour Tone
VDI, Verein Deutscher Ingenieure
1994
VDI 3882 Part 2. 19 p. Kommission Reinhaltung der Luft im VDI und DIN.
Germany
To evaluate a highly odorant substance or source other parameters than the odour threshold have to be considered such as its effect for above threshold concentrations on the olfactory sensation and its hedonic odour tone. The Guideline presents a method for evaluating the hedonic odour tone of odorant air mixes or gases. The hedonic odour tone of an odour should not be confused with the odour quality (referring to fragrant, stale, pungent or such) and is, in the guideline, represented by a position on a scale from 4 which is an extremely pleasant odour to -4 representing an extremely unpleasant one with 0 being neither pleasant nor unpleasant. VDI 3881 and VDI 3882 should be used for odorant concentration and odour intensity determinations. The procedures are given to realize the hedonic odour tone measurements and the results evaluation and presentation. The hedonic odour tone has to be considered in odour abatement evaluation, as reduction of the odorant emissions intensity may not always results in improvements of the hedonic odour tone. To evaluate a nuisance situation, frequency and duration of odorant presence in the ambient air have also to be considered.

This guideline gives interesting information and definitions of an important aspect of nuisance coming from odour, which is the hedonic odour tone. Olfactometry methods are used to evaluate many parameters characterizing odours that are more oriented in quantity evaluation. These procedures can be applied to pleasant odour sources or substances in the same way than for unpleasant odour source. The hedonic odour tone evaluation gives information on the human emotional reaction to odour, which is essential in odour evaluation and abatement.

ODO 6
Wirkung und Bewertung von Geruchen - Effects and Assessment of Odours - Determination of Annoyance Parameters by Questioning Repeated Brief Questioning of Neighbour Panellists
VDI, Verein Deutscher Ingenieure
1993a
VDI 3883 Part 2. 30 p. Kommission Reinhaltung der Luft im VDI und DIN.
Germany
A method of population survey is presented to evaluate the odour annoyance in a selected area as annoyance cannot be evaluated by physical chemistry methods. Selected local residents form a panel and are asked repeated questions at a given moment to evaluated their perception of odour. The annoyance caused by odour is quantify on a scale of 6 categories from 0 to 5 (0 is no odour, 1 is not annoying to extremely annoying which is 5) corresponding weighting factors are used for the analysis and the graphical representation of the odour annoyance. The survey can be done over a short period of time, which represents a short-term investigation with a test question at least one time a day for 2 to 3 months. Long-term investigation is done on a period of 12 to 14 months with a test at least one a week. Investigation zones have to be determined within the investigation area, which may be affected; by an odour source and a neutral control zone outside the investigation area is also chosen to compare the results with an unaffected area. The survey can be used: to evaluate the annoyance distribution in time and space for the investigated area, to demonstrate the difference between the annoyance situation in the investigated area compare to the neutral control zone, to evaluate the efficiency of applied odour abatement measures, to better understand the effect of prevailing wind direction and odour-relevant sources. Survey procedures are given with examples of letters and questioner. This method gives more relevant information than complaints surveys because a selected group of persons is invited to participate as for complaints only certain individual will forward complaints to local authorities. However the results of such a survey cannot be used for a different neighbourhood even if the conditions seem to be similar.

Very interesting and complete information is given on the way of doing odour annoyance survey. This tool is interesting because it can give a fairly good picture of the annoyance pattern in an area and relies directly on the population perception of

the odour source annoyance. Special attention has to be given to the survey organization and follow up to make sure that the procedures are understood and respected through out the survey period

ODO 7
Bestimmung der Geruchsstoffimmission durch Begehungen - Determination of Odorants in Ambient Air by Field Inspections
VDI, Verein Deutscher Ingenieure
1993b
VDI 3940 31 p. Kommission Reinhaltung der Luft im VDI und DIN.
Germany
In most cases the analysis of an odour in ambient air is complex because it is composed of mixed substances. Those substances taken individually are difficult and costly to measure because often their concentrations are low. The method described in the guideline evaluate an odorant in ambient air directly by use of human smell by measuring the percentage odour time (time fraction during one measurement duration when an odour is recognizable) and possibly the odour intensity (in a scale from 0 - no odour to 6 - extremely strong. VDI 3882 Part 1). Measurements are done over a period of 1 year or 6 months by a panel of assessors presenting certain characteristics (details about the panel selection are given in the publication). In the area where an emission occur an assessment area is defined according to the objective of the study. To evaluate the odour situation of this area, a grid is defined and covers the assessment area. Every corners of the grid squares become measurement points where one measurement of at least 10 minutes duration will be done at least 26 times a year. The field inspection methods will depend on the objectives aimed. The analyzed results of this whole procedure give information about the odour dispersion, odour plume and can be used for the validation of dispersion models and draw odour maps.

This guideline gives complete information about the determination of odorants in ambient air by field inspections. The procedures are well presented however no information where available about the reproducibility of the results. This test gives information about odour and other investigation should be done if the odorant composition has to be done to determine the presence of certain gases.

ODO 8
Biologische Abgas-/Abluftreinigung - Biofilter. Biological Waste Gas/Waste Air Purification - Biofilters.
VDI, Verein Deutscher Ingenieure
1991
VDI 3477, 32 p. Kommission Reinhaltung der Luft im VDI und DIN.
Germany
This guideline provides information about cleaning waste gas/waste air (WGA) to reduce or eliminate certain pollutants and odours by biological treatment in biofilters. Biofiltration has been used successfully to purify emissions from much different type of industries or productions including livestock production and manure treatment. Many odorant components (organic compounds such as oxygen-containing compounds, sulphur-containing compounds, nitrogen-containing compounds and inorganic compounds such as hydrogen sulphide and ammonia) are degraded in an aerobic process by the activity of the microorganisms settled on solid carrier substances. Compost, fibrous peat, heather, mixes of these of other organic substances and also lava or porous clay can be used and arranged in layer so the WGA can flow through and be absorbed onto the carrier substances surfaces where the micro-organisms can decomposed its components. To operate properly optimum conditions must be controlled in the biofilter such as WGA concentration and type, type, number and activity of the microorganisms in the biofilter, temperature, moisture content of the WGA and pH-value. Proper design and construction should be done and particular attention should be given in dimensioning the biofilter and start up and maintenance procedures. The efficiency of the biofilter will be evaluated by the reduction of specific pollutant or of the odour emission using different techniques (gas chromatographic and spectrometric analysis) for the pollutants and olfactometry for the improvement in the odour (VDI 3881 and 3882). The biofilter supplier has to guarantee the assured properties for define operating conditions.

Biofilters are effective for WGA reduction. However this technology, even if not very complicated, involves quite a bit of following up to maintain the proper conditions for micro-organisms activity and WGA reduction. The investment and operation costs of biofilters have also to be evaluated and weighted in the possible solutions for WGA reduction. Important operation cost are associated with the use of biofilters for treatment of waste air from ventilated livestock building as important volume of air has to be blown through the filter.

ODO 9
Reduction of Odorous Compounds in Pig Manure by Lowering Dietary Crude Protein
Heartland Lysine, Inc.
1997
Swine Research Report 25. Reducing Odor. Heartland Lysine, Inc. 8430W. Bryn Mawr, Suite 650, Chicago IL 60631. 4 p.
U.S.A.
An experiment has been done with a group of 27 pigs fed (at 95% of ad-libitum) a 2 phase feeding program (growing (G) from 35 to 65 kg and finishing (F) from 65 to 95 kg) and 3 diet treatments were applied: low protein (G: 138.2g crude protein (CP)/kg feed and F: 131.0g/kg), medium protein (G: 161.2g/kg and F: 139.9/kg) and high protein (G: 208.4g/kg and F: 189.2g/kg).

Environmental Issues Resource Centre

Odour Management

Lysine was incorporated in the diet. A nitrogen (N) balance was done to determine the N retained as lean tissues and the N excreted and analysis was realized on 10 components of the odor emission from the slurry to verify the effect of the treatment on variation of their concentration. The conclusions of this experiment are that: 40% less N was found in the slurry produce by growing and finishing pigs on the reduce CP diets compare to the high CP diet treatment; the concentration of the odorant components of the odor emissions decreased with the reduction of the CP in the diet; maximum lean tissue deposition is obtained with lowering the CP with an ideal balance of the essential amino acids (EAA).

The lower N level in the slurry obtained when reducing the CP level in the diet is interesting considering that the diet is balanced to maintain the EAA and allows a maximum lean tissues retention. The effect on certain components of the odor emissions can also be measured but unless olfactometric analysis of those emissions are done the reduction of certain components may not result in a lower odor intensity of on a better hedonic tone of the odorant.

Odour Management Technology for Pig Production Facilities

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To the reader

This brief review attempts to cover our most current knowledge of odour production and control. Further detailed information can be found within the references at the end of this booklet or by contacting the authors.

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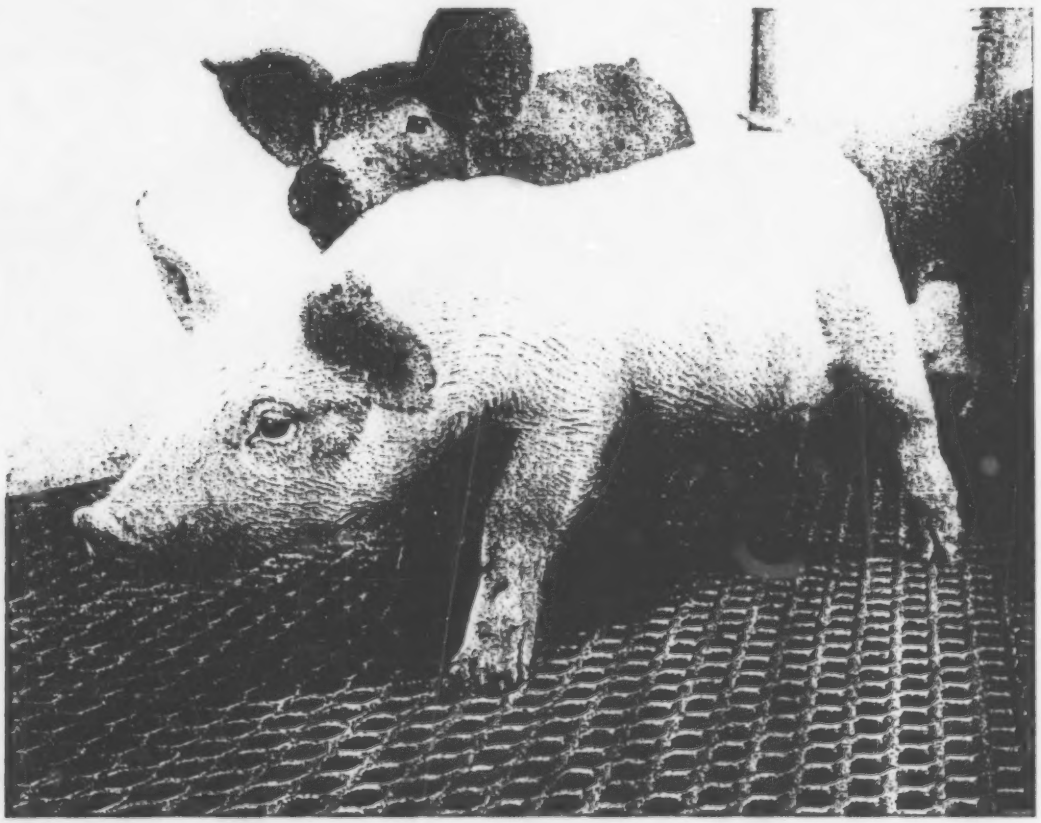
Introduction

Producers within the hog industry have a responsibility to ensure minimal impact on the surrounding area including odour-related issues.

Currently many management practices and technologies are in use to reduce manure odours on pork production facilities. They range from covers for earthen manure storage facilities to injection of manure slurry into the soil.

This booklet has been published to provide pork producers with practical information on current management practices and technologies. Specifically, this booklet deals with methods to reduce odour emissions from swine operations and their associated manure management systems.



Source: Prairie Swine Centre Inc.

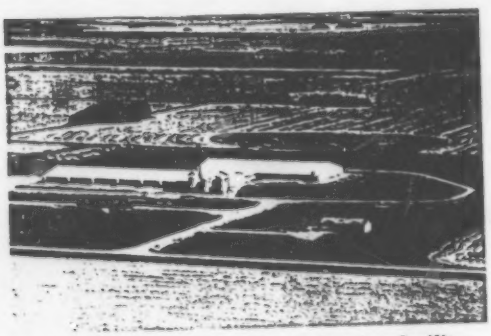
What Causes Odours?

On pig farms, odours originate from the pigs themselves, manure within the building, manure stored in facilities and later applied in the fields. Odour emissions also come from feed products and feed processing. Swine odours are complex, as they result from the mix of more than 165 identified volatile compounds. Interaction between those compounds are not yet well known and understood.

These substances can be classified into different groups of chemical compounds such as volatile fatty acids, phenols, nitrogen derivatives and sulfur derivatives.

The level of protein and amount of roughage in the animal's feed ration affects the generation of some compounds. The manure-handling system in the barn, from the barn to the storage facility and later to the field, affects the rate of odour generation and the characteristic smell.

Why is there an Increasing Emphasis on Odour Related Issues?



Aerial view of modern hog production facility.
Source: Quadra Management Services

Over the past few years there has been an increasing interest in the growth of the hog industry in Saskatchewan. This is especially true concerning issues related to odour. Some of the reasons for this emphasis are as follows:

- Historically in the prairies, the majority of the rural population consisted of "mixed farms" with small livestock operations. Now farms are more specialized and rural residents may have little or no experience with livestock and associated odours.
- The size of the livestock farms has increased considerably in the last decade.
- Non-farmers are moving into rural communities. This results in an increased sensitivity toward the introduction of new intensive livestock operations into the area.
- Some areas of the world have become very densely populated with livestock resulting in negative environmental impacts. The fear of repeating those mistakes in Saskatchewan concerns some people.
- The public has an ever-increasing awareness of environmental issues and this includes odour-related issues.
- Those who have never had any experience with hog operations may base much of their comprehension of livestock production on other people's opinions and not on real facts.

Here in Saskatchewan

Concerns about environmental issues, including odour due to the pig industry, are being addressed in the following ways:

- Saskatchewan maintains a regulatory framework with high standards relative to other jurisdictions in North America. This, along with current management practices and technologies used, ensures minimal odour emissions and other environmental impacts.

- Saskatchewan has a large landbase compared to its actual population allowing recommended separation distances to be met when constructing an intensive livestock operation.

- Our climatic conditions in Saskatchewan including hot summers, dry winds and cold winters, help to naturally disperse and reduce odour.

- Groups such as Saskatchewan Agriculture and Food, Prairie Agricultural Machinery Institute, Prairie Swine Centre Inc. and the University of Saskatchewan ensure that the most current research and information is made readily available to pig producers and the general public.

How the Human Sense of Smell Works

The sense of smell plays an important role in the human sensation of comfort. The smell perception is unique for each person and varies in time with the physical condition of the individual, the individual's memory of exposures to similar odours, and the odour emission conditions.

The smell reaction is the result of the stimulus created by the olfactory bulb (located on the top of the nasal cavity) being in contact with the odourous molecules. Signals are sent to the olfactory center in the brain through nerve fibers, where the odour impression is created and compared with the person's odour memory, based on individual perceptions and social background.

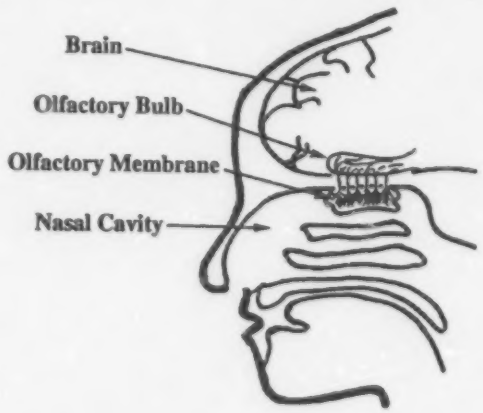


Diagram of the human olfactory system
Source: Pacific Science Centre. 1998

The extreme variability of sources, environmental factors, and human responses makes it difficult to measure odour emissions or determine an acceptable limit for pig-related odours. The offensiveness does not always correspond to its intensity or odour concentration. For instance, odours produced by agitating anaerobic slurries have been judged very offensive, even at low concentration, while odours coming from exhausted air of swine houses have been judged less offensive, even at much higher concentrations.

In cases where the odour becomes a nuisance the degree of the nuisance is determined by the following;

FIDO = Frequency X Concentration X Duration X Offensiveness

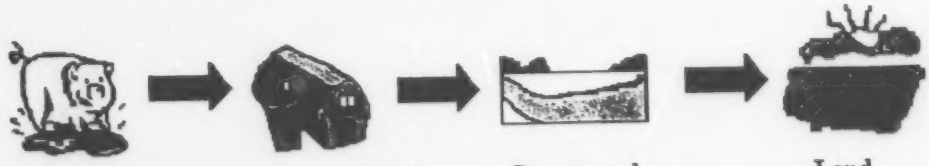
Lowering any one of the FIDO factors will reduce the nuisance perceived. Livestock operators can be sensitive to neighbours' concerns by managing their operation to minimize each of the FIDO factors.

What can be Done to Reduce Odour?

There are different methods that can be considered to reduce odours from pig farms. Four areas of pig production and manure management that can be focused on to reduce odour are:

1. Pig nutrition
2. Site and building consideration
3. Storage and treatment of manure
4. Land application of manure

To reduce odour emissions, measures first have to be taken in many, if not all, of these areas. Many of the techniques that are presently available have been used with success on commercial farm scale in Saskatchewan. Other odour control techniques are still under investigation, and reliable performance results have still to be obtained in order to justify the investment and labour required.



Potential odour control areas

1. Pig Nutrition:

Nitrogen, a key component of amino acids essential for pig growth, is found in the diet as protein. Pigs excrete excess nitrogen in their urine and feces when they ingest more protein than they can use to build muscle or maintain the body.

Dietary control

Filling feeders with pre-weighed feed
Source: Prairie Swine Centre Inc.

Nitrogen is also a key component of ammonia and other odourous compounds. A reduction of crude protein in the diet while providing the essential amino acid levels for growth can successfully result in less nitrogen being excreted by the pig while maintaining productivity. Consequently, certain selected odorants will be also reduced. Improved nutrient utilization also contributes to economical pork production.

Split feeding

Current research shows that using phase feeding, split sex feeding and balancing the diet based on ideal protein levels can reduce nitrogen output in the manure by 25 to 30% without reducing pig growth. This is achieved by reducing the crude protein of the diet and supplementing with synthetic amino acids.

Feed additives

Weighing feed for test diets
Source: Prairie Swine Centre Inc.

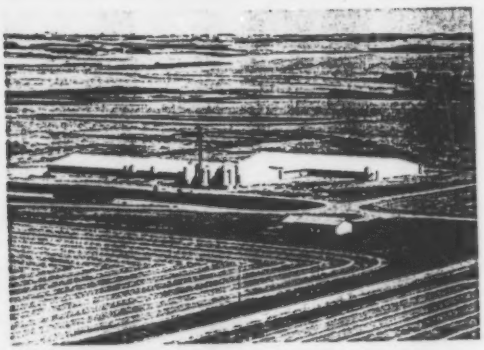
Odour control through the use of additives is an avenue that has to be better developed and investigated before it can be adopted as a standard practice. Further research is required to evaluate the real potential and practicality of such products. Their impact on feed intake and feed conversion has also to be investigated.

Animal fats and oils added to the feed can reduce feed-dust generation. This dust provides a carrier for odour compounds and transports outside the building by the ventilation system.

Feed additives such as calcium bentonite, zeolite and charcoal are formulated to adsorb odour-causing compounds such as ammonia.

Some of the most promising feed additives are plant extracts, enzymes, and direct-fed microbials, all of which may help control odour and improve growth performance in animals. Some research indicates that sarsaponin, a natural extract from the yucca plant, binds to ammonia and thus could help reduce certain odorants.

2. *Site and Building Considerations*



Siting the barn in a sparsely populated area reduces the impact
Source: Quadra Management Services

Siting considerations

In the preliminary stages of the development of a new hog operation, many factors must be considered, including the location of the site. Some general rules of thumb to follow when choosing a new site are:

- Ensure that there is adequate separation distance. A minimal separation distance to neighbours allows for odours dispersion without having to consider any particular management practices that would further minimize odour emissions.

- Consider prevailing winds in site selection to minimize the frequency of odour transport to neighbouring residences.

- Make use of naturally occurring windbreaks, shelterbelts and topographic features to provide natural odour dispersion and visual screening.

- Obtain sufficient land suitable for manure application according to soil and plant requirements. Agreements can be made with neighbours to fertilize their land with the excess manure produced on one farm.

Separation distances in the province may vary from area to area. Some municipalities have land use bylaws that specify separation distances for intensive livestock operations. Many rural municipalities use the separation distances taken from Saskatchewan Agriculture and Food Livestock Operations' "Guidelines for Establishing and Managing Livestock Operation" which are presented in Table 1. Those separation distances vary according to the size of the closer community and the number of animals on a given livestock facility. In Saskatchewan, one animal unit accounts for:

	3 boars or sows
or	4 gilts
or	6 feeder pigs
or	20 weanling pigs.

Table 1 Recommended Separation Distance, in Meters

	Animal Units					
Population	10-50	50-300	300-500	500-2000	2000-5000	>5000
Single Rural Residence	300 (450)	300 (450)	400 (600)	800 (1200)	1200 (2000)	1600 (2400)
<100	400 (600)	400 (600)	800 (1200)	1200 (1600)	1600 (2000)	2000 (2400)
100-500	400 (600)	800 (1200)	1200 (1600)	1600 (2000)	2400 (2400)	2400 (2400)
500-5000	800 (1200)	1200 (1600)	1600 (2000)	2400 (2400)	3200 (3200)	3200 (3200)
>5000	800 (1200)	1600 (2000)	2400 (2400)	3200 (3200)	3200 (3200)	3200 (3200)

Numbers in brackets are preferred for open liquid manure storage.
Source: Saskatchewan Agriculture and Food: Guidelines for Establishing and Managing Livestock Operations

Building considerations

Building design and operation practices have a substantial impact on odour control. Pen cleanliness has a major impact on odour emissions in a room. Within the building, the soiling of surfaces and pigs with manure also increases the odour emission rate.

Sources of odours in and around the building include:

- Wet, manure covered floors;
- Dirty, manure covered hogs;
- Spilled, moldy feed;
- Improper disposal of dead pigs;
- Deep manure pits under barn floors;
- Incinerators with incomplete combustion;
- Dust from feeders and barn surfaces resulting in higher levels of odorant as odour adheres to the dust and is moved outside the barn by the ventilation system;
- Increased room temperature increases emissions; and
- Feed preparation at the farm.

To reduce odourous emission:

- Ensure that pigs remain clean in the pens. If animals become dirty with manure, their body heat will promote the rapid release of odours.
- Pen scrapping, and removal of manure, reduces odour emissions and ammonia concentration in the room and its total emission into the environment.
- Regular washing and the use of easy to clean surfaces in barn construction considerably lower odour emissions.
- Limiting surface contact between ambient air and manure will help to reduce odours. Any steps, such as frequent manure removal to prevent anaerobic degradation of the manure within the building, will lower odour emissions.

Ventilation

Odours from ventilation air of livestock buildings can be a potential source of complaints from neighbours. The dispersion of gases and odours from the building depends upon the building shape, ventilation system, livestock numbers, manure management system and the conditions to be maintained in the building compared to the outside temperature.

The processes involved in odour emissions from a building are somewhat complex as, they vary with the ventilation rate of the exhausted air. The lower the ventilation rate, the higher the odour concentration is going to be close to the building. However with higher ventilation rates, the odour is diluted in a much larger air volume. The impact on the surrounding neighbours is going to be different depending on the air dispersion pattern outside the barn due to wind speed and direction.

Central ventilation which collects all exhaust air into on air stream is being used in Europe in order to treat the exhausted air that leaves the barn with different techniques.

Shelterbelts

Shelterbelts planted around a hog facility will improve the aesthetic appearance of the area and will reduce wind speed and help disperse odours. Windbreak buffers can be erected by planting multiple rows of trees to decrease the spread of odours by absorption and by creating greater loft to better dissipate and diffuse odours.

Technological developments

The following are various technologies that are currently being investigated. However, further research and development is required before they can be proven to be reliable in Saskatchewan.

odour masking agents

Masking agents are being investigated in Europe as a way to reduce the offensiveness of the exhausted air coming from pig barns. The masking agent is vaporized directly at the outlet of the fans or centralized ventilation system. An odour of banana, strawberry or other pleasant fruit or herbal mix is then predominant.

biofilters

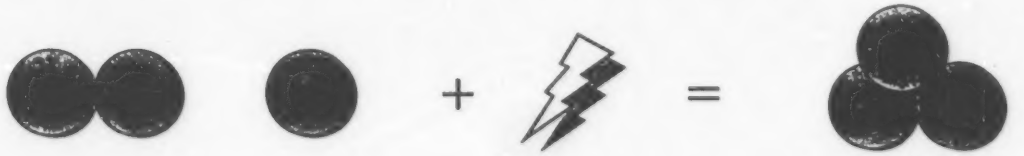
Biofilters can treat the exhausted air released from the barn as they absorb odour compounds. With biofilters, air is pushed through a porous bed of organic material (compost, peat, straw, soil, etc) that is kept moist. Dust and gaseous compounds are retained on the surface of the medium as well as adsorbed into the organic material. Bacteria present or added to the material convert those compounds into less odourous substances. The microorganisms present feed on the medium as well as on the nutrients present in the air that is passing through. Research results showed a 70% reduction in odour when compared to the levels of the air coming out of the barns with no treatment. Current research on biofilters used under colder conditions is underway in Alberta and Minnesota.

bioscrubbers

Bioscrubbers can be used to reduce odour emissions from outgoing ventilation air that has been centralized. Typically, these units are counterflow systems where water flows across a mat and the air to be treated is pushed through it. The unit is colonized with microorganisms creating a biological mat. The scrubbing water flowing across the mat, regenerates and supplies the bacteria with substrate and collects dust particles, odour compounds and different gases. This system can remove up to 70 - 80% of the ammonia load from the barn. However, it requires a supply of fresh water, and the disposal of the recycled water at regular intervals. The hog industry has not been adopting this technology on a large scale due to its complexity and high cost.

ozone generation

Research continues on the potential of ozone generation as a mean to reduce odours in pig barns. Ozone (O_3) is a naturally occurring substance generated by an electrical arc or ultraviolet radiation. The use of ozone generators in poultry and pig operations has been shown to reduce ammonia, hydrogen sulfide and other organic substances. Ozone oxidizes the organic substances, altering the compounds, thus reducing the odour characteristics. The ozone generator can be installed and used with existing ceiling ductwork distribution systems. Close monitoring of the ozone concentration in the building and adequate adjustment of the ozone generator system are necessary to provide a safe and healthy environment for the barn workers.



Ozone generation

3. *Storage and Treatment of Manure*

Manure can be treated in the barn or at the storage stage.

Treatments

Basic research on odour compounds interactions and emissions is still needed before practical and economical methods for odour control can be implemented from a manure management point of view. Research is being funded in many parts of the world to develop reliable products or techniques to abate odours. Techniques in odour measurement and comparison are also still being developed and tested.

pit additives

Pit additives vary greatly in their characteristics and modes of action. In many cases, the additive is a bacteria mix that will digest manure. Some additives will change manure consistency and homogenize it, others won't have any effect on the solid content. A recent survey showed that 78.9% of the 180 producers questioned used pit additives to solve their manure flow problems. Only 40.6% were satisfied with the odour reduction they obtained with the additives.

Other pit additives could be classified as odour masking agents. Those additives can also be added directly in the manure tank before application. The addition of masking agents results in no change in the manure characteristics other than changing its offensiveness. Some additives have a chemical action resulting in ammonia binding and also in the reduction of some bacterial activity.

Some products (Bio-surge, Gold 2000, Pit Boss, Shac, clinoptilolite) have been tested in research facilities and show some promise. However, more information is needed to better understand their range of application, and their limits within commercial farm operations. Pork producers interested in the most recent results should contact PSCI.

anaerobic digesters

Anaerobic digesters are large tanks used to anaerobically (without oxygen) decompose manure. Under controlled conditions, the digesters decompose the slurry, resulting in a less odourous product. Methane gas is produced in the digester and can be collected and utilized as an energy source. Digested pig slurry produces a less offensive odour than undigested manure while maintaining the slurry's nutrient value.

Methane production is affected by the digester temperature, the manure loading rate, the amount of mixing, digestion time and the characteristics of the manure.

The limiting factors in complete anaerobic digestion are the high cost of the digester, the ability of this equipment to perform well under our cold conditions and the expertise required to operate it.

Research is currently done by a joint team in Quebec and Manitoba to develop a low temperature anaerobic treatment that would control odor emissions and could be easily implemented on farms under our cold conditions.

Storages

Earthen manure storage sites are used in Saskatchewan to store liquid manure. The size of the earthen manure storage depends on the size of the facility and the storage time required. This type of storage system is relatively inexpensive and requires little maintenance.

The bacterial action occurring in manure storage can be divided into aerobic and anaerobic, depending on oxygen availability in the manure.

Earthen manure storage
Source: Saskatchewan Ag & Food

anaerobic storage

Anaerobic digestion occurs in manure in the absence of oxygen. Bacteria in the manure digests organic and other matter. This decomposition results in simpler compounds. During anaerobic microbial decomposition many compounds are produced. The most notable compounds are carbon dioxide, methane, ammonia and hydrogen sulfide.

Under cold conditions, bacterial activity is reduced, and can even stop, so complete anaerobic digestion cannot be obtained under Saskatchewan outdoor storage conditions. This situation results in odour emissions from the storage facility particularly when the manure is mixed and if the storage facility is not covered.

aerobic storage

Aerobic digestion occurs in manure in the presence of oxygen. Aerobic bacteria break down organic material much faster than anaerobic bacteria. Aerobic bacteria in the presence of dissolved oxygen convert organic matter to a stable form such as carbon dioxide, water, nitrates and phosphates.

Aerobic treatment results in reduced odour emissions, but can result in increased ammonia emissions. Loss of ammonia, which contains nitrogen, reduces the fertilizer value of manure and can contribute to acid rain. Aerobic conditions in earthen manure storage are obtained by: bubbling air or oxygen through the slurry, mixing the slurry mechanically, or pumping the slurry through the air. In order to stabilize and deodorize the manure, aeration has to be sufficient and long enough so all organic material is degraded.

Aeration by circulation can be achieved by impellers that turn and create a vortex in the manure allowing for an even distribution of oxygen.

There is no aerobic manure storage in Saskatchewan because of the operation costs and maintenance associated with such a system. Some storages are experimenting with wind driven aerators. Further research is needed to determine if there is any benefit for these types of low cost, low energy systems.

Covers

Covers can be very effective methods to reduce odours from manure storage units.

barley straw covers

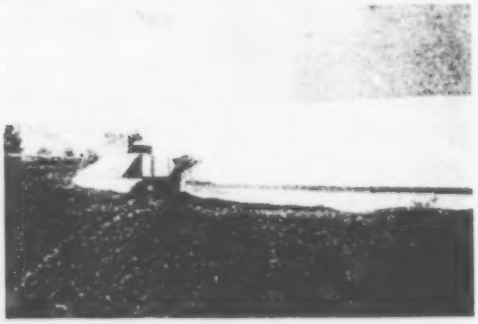
Straw being added to an earthen manure storage.
Source: Prairie Agricultural Machinery Institute

Prairie Agricultural Machinery Institute (PAMI) has concluded that barley straw can provide excellent odour control as long as the straw floats and remains dry. With a straw applicator to provide uniform coverage, 6 - 10 inches of good quality barley straw has been shown to decrease odour by 90 -95%.

When 15% of the earthen manure storage area has open liquid because of straw sinkage, reapplication of straw would be necessary. Generally only one reapplication within a year is required.

Before using barley straw on the surface of liquid manure, ensure that the manure removal and application equipment that is generally used is capable of handling the extra fibrous or organic material. This may require a chopper blade on the agitator or a rotary cutting and /or distribution system prior to the slurry injector.

flexible - type covers



Balloon cover on a concrete manure storage system
Source: Prairie Swine Centre Inc.

At Prairie Swine Centre, the use of a hypalon roof covering tarp on a concrete storage tank has proven to be a very effective and economical method of reducing manure odour during storage. The plastic tarp representing one-fifth of solid structure covers is sealed tight around the perimeter of a concrete tank and inflated using a low-pressure blower requiring the power equivalent of a 250-watt light bulb.

In the Prairies, some developments are currently done on a flexible cover using negative air pressure to secure it over earthen manure storage facilities. Other floating devices are being developed and tested for earthen storage facilities in the U.S.A.

Compost

Composting is an aerobic process that requires oxygen. The organic material degradation is done by microorganisms under controlled conditions. Nitrogen and carbon are essential nutrients for growth and production of microbial cells in the decomposition of complex organic compounds. The amount and form of nitrogen required and carbon source used

(wood shavings, straw, etc.), varies with the type and concentration of material to be treated. For composting pig manure a carbon to nitrogen ration around 30:1 and moisture content of 50 - 60% is reported to be effective. This requires the addition of material such as straw, leaves, sawdust or paper to the liquid manure.

The end product is a more stable form of organic matter and nitrogen. The nitrogen in the compost is stabilized into organic forms that are less volatile allowing for more nitrogen to be retained for use in crop production and less volatile odourous compounds produced.

Aerobic composting will not produce high levels of objectionable odours if properly managed. The primary end products of aerobic decomposition are carbon dioxide, water and heat. If the pile contains adequate amounts of material such as straw, proper temperature and aeration, little odour will be given off. By aerating the manure using a mechanical turner, the rate of decomposition is greatly increased. However, cold weather can slow down the microorganism activity considerably.

Challenges to composting pig manure include the low solids content (typically 5% total solids) but with the addition the correct amount of materials such as sawdust, or liquid-solid separation composting can be accomplished.

Constructed wetlands

Wetlands have the natural capability of filtering out nutrients such as nitrogen, phosphorous, and potassium, from the water. Constructed wetlands mimic the functions of natural wetlands. Plants, such as cattails and bulrushes utilize these nutrients resulting in cleaner water.

Proper sizing and management of a wetland area results in cleaned water that can be released to the natural watercourse, as the nutrients have been retained in the vegetative material.

Because wetlands do not function during the winter, constructed wetlands designed for the Prairie region will need to be sized to complete all of the treatment in a 6-month period or less.

Wetland plants required, such as cattails and bulrushes, grow well in the Prairies. The limiting factor of constructed wetlands is that there is a high capital cost involved in building such a system.

Further research is required to determine the feasibility of wetlands to manage manure.

4. Land Application of Manure

Land application should be well coordinated to minimize impact on neighbours. General considerations regarding schedule for land application are as follows:

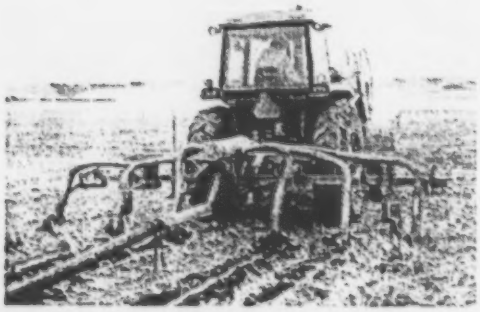
- Inform neighbours of application, and avoid spreading during weekends.
- Apply manure on days when the wind is blowing away from neighbours and dwellings.

- Complete manure application as quickly as possible. Reducing the frequency and duration of the manure removal and application process will minimize the possibility of conflict with neighbours.

- Whenever possible, manage manure applications so that it is applied only once or twice a year.

- Inject properly in accordance with soil conditions.

Injection of manure slurry



Manure being injected into the soil
Source: Prairie Agricultural Machinery Institute

Manure slurry injection is the most effective way to reduce odour during land application. Injecting slurry into the soil reduces or prevents odour problems and ammonia losses.

To minimize odour, the manure should not be exposed to the atmosphere. Avoid high injection rates that leave manure on the surface, or injectors that are not fully engaged in the soil (for example at the beginning and ends of the field).

PAMI has developed a cultivator-based high-volume injection system which:

- Reduces odour during the application process;

- Reduces potential nitrate pollution due to over-application;
- Provides well-distributed nutrients for efficient crop use;

- Include a rotary cutter which can handle slurry trash such as straw, hair, and other foreign material; and

- Operates in fields with 8 to 10 inches of heavy barley stubble.

Solid spreading

Solid manure is sometimes piled or spread in fields, leveled then soil incorporated. Incorporating the manure within 24 hours of leveling will minimize odour nuisance.

Minimal-till application

Incorporating manure with a disk applicator allows producers to use manure on highly erodible land without losing ground cover. This type of system allows for minimal disturbance of the field while producing minimal odour during application.

Currently mirimal-till application of manure is being investigated by PAMI for the Prairies' conditions.

Guidelines and regulations

Table 2 refers to the minimum recommended separation distances for manure application, as found in Saskatchewan Agriculture and Food's "Guidelines for Establishing and Managing Livestock Operations.

Table 2 Minimum Recommended Separation Distances for Manure Application *

	Distances, meters		
Population	**Injected**	**Incorporated within 24 Hrs**	**No Incorporation**
1-1000	200	400	800
1001-5000	400	800	1200
>5000	400	800	1600
For Water Protection			
Domestic groundwater supply on land not controlled by the operator	100	100	100
Watercourse or body of water not contained on land controlled by the operator to which runoff water ***will not*** flow	30	30	30
Watercourse or body of water not contained on land controlled by the operator to which runoff water ***will*** flow	30	150	300

* ***recommendations based on providing public comfort.***

Source: Saskatchewan Agriculture and Food: Guidelines for Establishing and Managing Livestock Operations

5. *Costs of different odour management techniques*

As mentioned, simple measures can be taken to control odours including having adequate separation distances and keeping the facility clean. If any particular techniques are used to reduce the impact of odours, an associated cost comes with it. The following figures attempt to give an idea of the magnitude of those costs.

The values given in Table 3 have to be used with caution, as they were gathered from different sources in North America and Europe and do not represent a controlled economic comparison.

Table 3 Manure Odour Management Costs

Technology	Associated cost CAN$
Feed additives and Manure additives	$8.70 to $50.75 per livestock unit/year (Buscher et al. 1997) $0.95 per pig produced (AURI, 1997) $12.93 per sow-place $2.45 per pig-place (Guingard et al., 1998)
Straw manure storage cover	Straw $20/1000sq ft $169.74/hour - 5 hrs for 8 M gallon EMS all annual costs (PAMI, 1999)
Balloon manure storage cover	Invest: $5000 + $2000 labour (5 - 10 years) +electricity (Zhang, 1996)
Soft plastic cover	Invest: $25 000 (5 years) $200 operation / year (D.G.H., 1999)
Biofilters	$0.40/ piglet produced in farrowing (Nicolai and Janni, 1997)
Bioscrubbers	$12.75 to $24.15 per pig produced (Lais et al. 1997)
Shelterbelts	$685/km, one row of trees with herbicide treatement $760/km, one row of trees with weed control plastic cover. Could vary with tree species. (PFRA, 1999)

Table 3 Manure Odour Management Costs (continued)

Technology	Associated cost CAN$
Ozone generator	Invest: $45 000 (10 to 20 year life expect.) $1400 elec. + $500 maint. / year (Environ, 1999)
Anaerobic digestor and Aerobic systems	1.07¢ to 2.17¢ / gallon of manure treated (ITP, 1998) $5.72 per pig produced (CRIQ, 1994)
Constructed wetland	$20 000 to $30 000 per acre for compacted and clay lined installation $6 000 to $12 000 per acre for unlined installation (SAF, 1999)
Manure injection	1¢ per gallon of manure injected (PAMI, 1999)
Mixed treatments (separation then biofilter for liquids an anaerobic treatment for solids)	2.27¢ to 9.09¢ / gallon of manure treated (Gingras and Pigeon, 1998)

Conclusion

Pork producers are taking a pro-active approach in reducing odour emissions from their operations. Good management and utilization of current technologies in areas such as nutrition, site and building considerations, storage and treatment of manure and land application of manure can result in minimal odour from pig production facilities. This approach will ensure that the pork producers can be good neighbours.

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For further information of the above please contact:

Prairie Swine Centre Inc.
Lee Whittington
(306) 373-9922
whittington@sask.usask.ca

Prairie Agricultural Machinery Institute
Darrell Lischynski
(306) 682-2555

SAF
Agricultural Operations Branch
Bill Henley
(306) 933-5095
bhenley@agr.gov.sk.ca

Pork Central
Karen Bolton
(306) 787-9183
kbolton@agr.gov.sk.ca

References

AURI, Agricultural Utilization Research Institute. 1997. Final Report. "Evaluation of Commercial Manure Additives". Agricultural Utilization Research Institute. Jack Johnson, P.O. Box 251, Waseca, MN 56093.

Bundy, D.S., 1997. *Environmental Issues in Pork Production: Odor Control Techniques.* Minnesota Extension Service, University of Minnesota. Pp. 59-69.

Buscher, W., E. Hartung, T. Jungbluth. 1997. Examining the performance of additives in reducing the odor and ammonia emissions from slurry with a standard test procedure.. Paper 974121. 1997 ASAE Annual International Meeting. August 10-14, 1997. ASAE, 2950, Niles Road, St. Joseph, MI 49085-9659, p. 7.

Chénard, L., L. Whittington, S.P. Lemay. 1998. *An Analysis of Environmental Issues and Legislation Impacting on the Establishment and Expansion of Livestock Production Units in Ontario: Environmental Issues Resource Centre.* Prairie Swine Centre. 21 p.

Comfort, S. 1997. *Manure Application: Odor and Related Nuisances.* University of Nebraska-Lincoln, Department of Agronomy. Electronic Document: ianrwww.unl.edu/ianr/agronomy/Manure22.htm

CRIQ, Universite Laval, Les Consultants BPR. 1994. Rapport synthese - Inventaire et etude comparative des technologies de desodorisation et autres methodes et pratiques d'attenuation des odeurs de lisier. Dossier CRIQ no: 640-PE03364, Rapport Technique no: RDQ-94-040. Prepare pour le Ministere de l'Environnement e de la Faune. MEF. Quebec.

DGH Engineering LTD. 1999. Personal contacts. St. Andrews, Manitoba.

Envron Inc. 1999. Personal contacts. Regina, Saskatchewan.

Gingras, G., S. Pigeon. 1998. Conference presented at AGRI-VISION. December 8. St-Hyacinthe, Québec.

Guingard, N., G. Guillaume and J.P. Quillien. L'utilisation d'additifs du lisier de porc. Techni-Porc. Janvier - Février 1998. No. 1. Pp. 17-18.

Hobson, P.N., A.M. Robertson. 1977. *Waste Treatment in Agriculture; Aerobic Methods.* Applies Science Publishers Ltd. London England.

Houghton, D. 1997. *High-tech injection: Precision farming and conservation techniques add value to injected manure.* Hogs Today. October 1997. Pp. 26-27.

ITP. Institut Technique du Porc. 1998. Odeurs et environnement. Cas de la production porcine.

Lais, S., E. Hartung and T. Jungbluth. 1997, Reduction of ammonia and odour emissions by bioscrubbers. Ammonia and Odour Control from Animal Production Facilities. Proceedings of the International Symposium. Vinkeloord, The Netherlands. October 6-10, 1997, pp. 533-536.

Lapp, H.M., D.D. Schulte, A.B. Sparling, L.C. Buchanan. 1975. *Methane Production from Animal Wastes. 1. Fundamental Considerations.* Canadian Agricultural Engineering. Vol. 7 No. 2. December 1975. Pp. 97-102.

Meyer D.J., J.C. Converse. 1982. *Controlling Swine Manure Odors Using Artificial Floating Scums.* 1982 Transactions of the American Society of Agricultural Engineers. Pp. 1691-1695.

Mills, B. 1994. *Constructed Wetlands.* Hogs Today Feburary 1994. Pp. 32-33.

Miner, J. Ronald. 1995. *A Review of the Literature on the nature and Control of Odors from Pork Production Facilities.* Bioresource Engineering Department , Oregon State University Corvallis. Pp. 1-21.

Miner ,J. Ronald, Syed Navaid Raja, Wallace McGregor, 1998. *Finely Ground Zeolite as an Odour Control Immediately Prior to Sprinkler Application of Liquid Dairy Manure.* Proceeding of the International Symposium, Ammonia and Odour Control from Animal Production Facilities. Pp. 715-720.

Nicolai, R.E. and K.A. Janni. 1997. Development of a Low Cost Biofilter for Swine Production Facilities. Paper 974040. 1997 ASAE Annual International Meeting. August 10-14, 1997. ASAE, 2950, Niles Road, St. Joseph, MI 49085-9659, p. 8.

Pacific Science Centre. 1998. *How do you Smell?* Electronic Document: http://www.pacsci.org/public/education/champions/smell2.html#brain

PAMI, 1999. Personal contacts. Humbolt, Saskatchewan.

PAMI 1993. Research Update 698:Hog Lagoon Odour Control: A Treatment Using Floating Straw.

Patrico, J. 1994. *The Dilution Solution: Iowa Select experiments with new manure management systems to cut odor.* Hogs Today November 1994. Pp. 28-29.

PFRA. 1999. Personal Contacts. Indian Head, Saskatchewan

Russell, J. 1995. *Good neighbours.* Hogs Today. November 1995. Pp. 26-27Saskatchewan Agriculture and Food. 1998. *Guidelines for Establishing and Managing Livestock Operations.* Saskatchewan Agriculture and Food Livestock Operations.

SAF, Saskatchewan Ag & Food. 1999. Personal contacts. Saskatoon, Saskatchewan.

Seim, D. 1995. *Separating the odor:* Hogs Today January 1995. Pp. 8.

Swine Odor Task Force. 1995. *Options for Managing Odors.* North Carolina Agricultural Research Service, North Carolina State University. Pp.9.

Silsoe Research Institute. 1997. *Reducing Ammonia Emissions from Slurry Stores.* Environmental Engineering at Silsoe Research Institute 1997-98.

Toombs Micheal R. 1997. *Evaluation of a Wind Powered Aerator to Control Odours from a Liquid Manure Storage.* Ontario Ministry of Agriculture and Food.

Welsh, F.W., D.D. Schulte,E. J. Kroeker, H. M. Lapp. 1977. *The Effect of Anaerobic Digestion Upon Swine Manure Odors.* Canadian Agricultural Engineering. Vol. 19. No. 2. Pp. 122-126.

Zhang Y.,W. Gakeer. 1996. *A Low Cost Balloon-Type Lagoon Cover.* Prairie Swine Centre Inc. 1996 Annual Research Report. Pp. 54-61.

Zhang, Yuanhui. 1994. *Swine Building Ventilation: A Guide for Confinement Swine Housing in Cold Climates.* Prairie Swine Centre Inc. Pp. 3-4.

INTERIM REPORT

on the Project

Controlling Manure Odours from Swine Operations

A Demonstration and Education Project

Funded by Agri Food Innovation Fund (AFIF)

January 29, 1997

Submitted by Lee Whittington
Prairie Swine Centre Inc.
P.O. Box 21057, 2105-8th St. East
Saskatoon, S7H 5N9

306-477-7447

PHASE I

MANURE ODOUR CONTROL FIELD DAY FOR MEDIA AND REGULATORS

W.T.(Bill) Henley[1] P. Eng., D.L. (Lee) Whittington[2], B.Sc., M.B.A.
[1]Agricultural Operations Section, Saskatchewan Agriculture and Food,
[2] Prairie Swine Centre Inc., Saskatoon

Background

The hog industry in the prairie region of Western Canada has a competitive advantage over other Provinces and areas of the world with respect to cost, animal density, high herd health status and management expertise. These factors combined with moderate to good pork prices over the past five years have lead many traditional as well as new entrants to expand their production. Expansion has included an increase in farm size. Typical new farm size is either 600 sow farrow to finish sites which are planned to expand to 1200 sows or 2400 sow SEW (Segregated Early Weaning) operations with 2400 sow space farrowing sites, 8800 pig space nursery sites and 8000 pig space feeder sites. Saskatchewan has traditionally had a very small hog industry, which for many years has produced approximately 1 million feeder hogs per year. These hogs were produced on more than 4000 farms 10 years ago. Today this same number of hogs are being produced on 2200 farms. Less than 100 of today's 2200 producers produce more than 80% of these pigs. Projections indicate that 3 million hogs will be produced in Saskatchewan in 5 years time.

This small concentrated industry is not well understood by the rest of society in Saskatchewan or even by the rest of the agricultural industry in this Province. The hog industry has been negatively affected by headline grabbing "horror" stories from other jurisdictions. Technologies that directly address manure management, including odour control, have been developed here. These technologies and their effectiveness are is not well known outside the industry. Consequently this phase of the project focuses on the need to make people aware of these developments. In short, it is the industry's responsibility to demonstrate that it is dealing effectively with one of the problems to expansion of pig numbers.

Tour Design

Through funding provided by the Agri-Food Innovation Fund (AFIF) a demonstration tour was set for July 29/97. The purpose of the tour was to actively demonstrate cost effective methods of odour control in the storage, agitation and application of manure that can be used on commercial hog farms today. The organizers of the tour were the Prairie Agricultural Machinery Institute (PAMI), Saskatchewan Agriculture and Food (SAF) and the Prairie Swine Centre Inc (PSCI).
The tour was targeted at media, municipal politicians and provincial employees involved in regulatory or industry support roles. The media was targeted because of their impact on public opinion. Municipal politicians were chosen because of their involvement in site selection at the local level. Provincial regulatory employees were included because of their involvement in the approval process for the establishment of new facilities. All three of these groups can have a major impact on the growth of the industry. Personal invitations were sent to all participants and follow up was done with each invitation to ensure attendance at the event. Everyone was asked to be part of the group who traveled from site to site on the tour bus. This helped to alleviate the concern of biosecurity on our host farms (swine farms protect the health of their herds by restricting visitors which may have come into contact with other pigs or pig manure). A further benefit of having participants travel together is the opportunity to encourage discussion with resource staff which organized the tour and provided technical expertise. All participants except the television media were able to ride the bus.

Television reporters and their camera staff followed along behind the bus. A meal was planned beside an earthen manure storage for the end of the event to illustrate how well odour can be controlled. The event itself was promoted with media releases prior to and on the day of the tour.

The Tour

The day started with everyone meeting at a mall in Saskatoon to board the bus. An information package was distributed to everyone in attendance. It consisted of a brochure on the AFIF project, information from PSCI on their inflated balloon cover, information from PAMI on various aspects of manure management and odour control, as well as articles of general interest on manure and odour most of which were taken from hog trade magazines. A video produced by PSCI on biosecurity was shown on the bus trip to the first stop of the tour.

The first stop was PSCI where an inflated, **balloon type cover** on a 60' diameter, 12' deep circular concrete tank was demonstrated. The design and operation of the inflated cover was explained by Dr. Stephan Lemay, Engineering Research Scientist. PSCI also has an identical concrete tank that is not covered so that, participants could notice the significant difference in odour levels between the two storage vessels.

The second stop was an 8800, pig space nursery site where the manure is stored in a 200' by 400' clay-lined earthen manure storage. **No odour control** measures were in use at this site. The purpose of the stop here was for participants to establish a baseline for perceiving odour level and to determine fist-hand whether the odour was offensive. It had been determined in advance that many of the participants had never seen an earthen manure storage and that much of their reaction to pig manure to-date was based on other people's opinions.

The third stop was a 600, sow farrow to finish site where the manure is stored in an earthen manure storage. This particular barn uses a **pit additive** in the barn to reduce odour and to improve the solids handling of the manure at pump out. The PAMI-developed **Pit Sweep** was also demonstrated at this site in comparison to conventional earthen manure storage agitation methods. The Pit Sweep consists of a horizontal hydraulically driven rotating auger and shield attached at the open impeller end of a conventional lagoon pump. It can stir up solids and drag them to the impeller with very little disturbance of the liquids at the surface, thus reducing odour emissions and fuel consumption compared with continuous conventional agitation.

The fourth stop was in a field where the PAMI-developed **liquid manure injection** system was demonstrated. This system consists of a modified cultivator with a distribution head and shanks on 12 " row spacing so that manure can be evenly applied below the soil surface. The system has been designed to handle slurry trash such as hair, straw and other foreign materials without plugging. It also operates in fields with very heavy surface residues and long stubble.

The final stop was at a earthen manure storage where the liquid surface had been **covered with barley straw** approximately 30 days previously. Some of the straw surface had blackened and sunken below the surface of the liquid by the time of the demonstration but participants could notice the significant reduction in odour levels caused by the straw cover. Additional straw was blown on the liquid surface using a machine manufactured by Highline Manufacturing called the "TopGun". This machine consists of a large round bale processor with a centrifugal fan and nozzle attached. After new straw was added the odour level at the storage was considered to be zero.

Conclusion of Tour

The day was completed with a catered full course hot meal being served beside the straw covered earthen storage. This was done to reinforce the point that there are steps that producers can and are taking to significantly reduce the odour level in the storage, handling and spreading of liquid hog manure. The meal was delicious, everyone ate (even those who declared at the start of the tour that they wouldn't be able to eat seated beside a manure storage site) and many people had second helpings.

Media Activity and Follow up

One of the main objectives of the day was to have the media file stories of what they saw and smelled. Prior to the actual event and on the day of the event two media releases were put out explaining the event, and giving the name of a contact person. On the day of the event a reporter with CBC radio did a "live" broadcast with Lee Whittington on the noon hour show as the tour was in progress. In the afternoon the same reporter did another story for the 4 to 6 PM show. As well, for the two following days stories ran again during a different part of the day and a follow up story was provided by the CBC. Two television crews covered the event. They both filed evening stories on the day of the event as well as follow up stories later in the same week. Print media ran stories in the following publications: The Western Producer which is read in all 3 prairie provinces; Ag World which is distributed free to all farmers in Saskatchewan; and in the Humboldt Journal which is the newspaper covering the area where most of the tour was held. As well Saskatchewan Agriculture and Food issued it's own press release on the event where the media in attendance at the event were quoted on their impressions regarding how well the odour reduction methods worked. The release went as follows:

Week of August 25, 1997

HOG INDUSTRY'S NEW ODOR-CONTROL TECHNOLOGY IMPRESSES MEDIA

As with any good journalist, CBC Saskatoon radio reporter Amy Jo Ehman approaches every news story with an open mind. Her response to the invitation to attend the Agri-Food Innovation Fund Manure Odour Control Field Day in late July, however, was slightly different.

"I expected hog manure to stink," she confesses.

And it did -- but not near as badly as she expected.

"I attended the field day because the issue of odor control in hog operations has raised a lot of public controversy, and I wanted a first-hand look," Ehman explains. "We weren't in the barns, but we were given a demonstration of a new machine that injected the swine manure directly into the ground. This produced no smell at all.

"One of the most interesting events was our lunch beside a manure pit. The pit was covered with straw, and we could eat there with no problem at all. That was a big surprise," says Ehman.

The latter included a straw-blowing demonstration with a TopGun machine by Highline Manufacturing Inc., says Denise Phipps, a summer employee of Pork Central, Saskatchewan Agriculture and Food in Saskatoon.

Phipps organized the late-July Manure Odour Control Field Day to allow members of the media and representatives from various companies and agencies, such as SaskWater and Canadian Imperial Bank of Canada, to experience the olfactory effects of various odor-control techniques emerging on Saskatchewan farms. Participants visited two commercial pork production facilities near Humboldt -- Big Sky Pork and Possberg Pork Farm 1 -- and Paul and Judy Ulrich's hog farm near Spalding.

"In addition to the TopGun demonstration we showed the effect of a pit additive product that controls odor by reducing the ammonia loss," says Phipps.

"The Prairie Agricultural Machinery Institute (PAMI) demonstrated its Pit Sweep, which will likely revolutionize the future of pit agitation in large swine operations. PAMI also

demonstrated its cultivator-based, high-volume manure injection system. The main advantage of this system over the traditional broadcast methods is odor reduction, but it also retains more of the valuable crop nutrients."

Ed White, a Saskatoon reporter from The Western Producer, admits he was skeptical about the alleged benefits of these new odor-control technologies.

"I know hog manure can be horrific," White says. "But I was particularly struck by how well the straw cover over the lagoon worked. That's where we had the barbecue and there was no smell at all. I was also impressed with the comparison of the old and new lagoon agitation methods."

Marilyn Maki, a reporter with CBC Television in Saskatoon, attended the demonstrations of the Pit Sweep and PAMI's field injection system only. The odor reduction of both systems impressed her.

"It's nice to see the hog industry is addressing the odor problem with technology that seems to be effective," she concludes.

The entire field tour was attended by Murray Lyons, a Saskatoon Star Phoenix reporter who has had previous experiences on the traditional hog farm. He was most impressed by PAMI's direct-injection system.

"If this system was widely used, I don't think there would be any great objection to the distribution of hog manure," says Lyons.

"But I was kind of apprehensive about the prospect of eating lunch beside the outdoor storage pit. I was generally impressed by the straw-blowing demonstration. We were quite comfortable eating there.

"So I left this field tour with the impression that the odor from swine operations is a manageable problem. And it seems the industry is working hard to deal with it," says Lyons.

For more information, contact: (name and address of Bill Henley)

Evaluation and Further Development

Participants in the tour were asked to formally evaluate the event. Almost all ratings were in the very good to excellent range, especially in the areas of usefulness of information and quality and content of demonstrations. Interesting comments to note were: 1) the need to do this type of field day in other parts of the province, and 2) the desire by people outside the pig industry to see, hear and touch a real pig.

Printed material as well as a video on odour reduction are in the process of being developed over the winter months in 1997/98. A tour is also tentatively being planned for the southern part of Saskatchewan for the spring of 1998. Other technology developments that will hopefully be demonstrated include the use of a pipeline direct injection system and the use of liquid manure pumping equipment that effectively handles the straw from a straw cover.

This tour is part of a larger project, which has as its objectives the development of written information on odour control, the production of videos on odour control as well as the demonstration tour.

Attachments
press clippings
evaluation forms summary
Swine Odour brochure

F2

FILE

Dr. Abdul Jalil
Agri-Food Innovation Fund
3085 Albert Street,
Regina, Saskatchewan
S4S 0B1

September 21, 1998

Dear Dr Jalil:
Subject: Reducing Odour From Manure, Project 96000498

Summary
The AFIF project "Reducing Odour From Manure" was funded to allow the development of written materials, video information, and a tour discussing cost effective methods of reducing manure from swine operations.

The project has progressed well and has efficiently utilized the funding available. Through the cooperative efforts of team members: Bill Henley, Agricultural Operations Branch, Saskatchewan Agriculture and Food; Karen Bolton, Manure Management Specialist, Pork Central; Darrell Lischynski, Energy and Processing Manager, PAMI; and summer student Sherry-Lynn Perih, significant achievements have been made and additional goals set for the project within the original budget allocated.

This interim report identifies the achievements to-date. These activities have resulted in budget savings in the areas of video production and literature search through the effective partnering with groups having similar objectives. Due to these economies, high quality informational materials will be made available to more people in Saskatchewan. With the additional cooperation however has come additional time to communicate and produce an acceptable product. With a small surplus anticipated at the completion of all current commitments we propose to operate a third swine odour tour in June 1999. This will be targeted specifically at local decision makers – municipal councilors and their administrators. This group was identified on this year's tour as wanting additional information and playing a significant role in new facility approvals.

Thus our team respectfully requests an extension of the funding period to June 30, 1999. This will allow all materials under construction to be completed and exposed to the widest possible Saskatchewan audience and allow additional effort on a new target group – municipal councilors. All of this additional effort can be accommodated in the original budget and the group is not asking for additional funds but wishes only to continue to utilize the funds allocated to continue to educate key players and the general public about swine odour and the ways it is being abated or controlled on commercial swine farms in Saskatchewan.

Tour 1998
A tour held on July 15th demonstrated cost effective methods of odour control during storage, transportation and application of liquid manure at selected hog operations in the Regina area.

The tour program consisted of a visit to pork production units in the Regina area to address the various odour control techniques which are emerging on Saskatchewan farms, such as the use of straw covers over earthen manure storage and direct injection of manure slurry into a field.

The Alberta Research Council along with Alberta Agriculture, Food and Rural Development, Alberta Pork Producers Development Corporation, and the University of Alberta have developed a mobile unit used for detecting and quantifying odour, especially from intensive hog-rearing operations. This new technology was demonstrated to the guests on the tour.

Participants were able to experience this new technology first-hand by participating in an odour evaluation panel. The lab featured two instruments; the Aroma Scan which has the potential to identify types and sources of odours, and an olfactometer which measures the intensity of odours. Once the source of nuisance odours are accurately identified in existing operations, they will be able to create predictive tools using air dispersion models. These tools will be useful in evaluating odour impact when planning future livestock expansions. This lab feature complemented the farm site and field injection demonstrations which showed currently used technologies.

This year's tour built on a tour held last year in the Saskatoon/Humboldt area. Last year's tour included a stop at Prairie Swine Centre Inc., where an inflated, balloon type cover on a concrete manure storage tank was demonstrated. This cover effectively reduces odour from the concrete manure storage at $1/5^{th}$ the cost of a concrete cover.

The tour also included a discussion regarding other studies, including sprinkling a small amount of canola oil in the barn to reduce dust and gas concentrations. Hydrogen sulphide and ammonia concentration were reduced by 56% and 26% respectively. Several farm site visits and a demonstration of lagoon pumping and field injection by PAMI staff rounded out the morning program.

Last year's tour concluded with a picnic lunch beside an Earthen Manure Storage (EMS) recently covered with straw. The lunch was enjoyed by all and demonstrated the effectiveness of this technology to suppress odour from storage.

Guests of both tours, including provincial media, government officials and rural municipality members, experienced the technology first-hand allowing participants to see what producers and researchers are doing to reduce odour from pig production operations.

Written Material

Written material has been developed which focuses on current methods and technologies used to reduce manure odours. This material will be presented in a 20-page booklet to provide a practical guide of current practices and technologies available to control manure odour. This detailed guide will be targeted at and distributed directly to pork producers in Saskatchewan.

Currently the material has been given to a select group of individuals for an external review of the document. The reviewers include SAF, Pork Central, University of Saskatchewan and several Saskatchewan Pork producers. The external review is designed to ensure that the information included in the booklet is relevant and feasible for use in the hog industry.

Once the review has been completed, 3000 copies of the material will be printed. This will allow the material to be distributed widely to pork producers and others interested in methods to control odour. A copy of the proposed cover and Table of Contents is attached.

The literature search of published scientific findings in odour reduction and control as outlined in the Information Database section below will also be available in written form.

Video

Development of a video targeted at the general public dealing with odour issues and control practices has been reviewed and is a feasible component of the project. This activity has been helped in its distribution plan and financial development by joining a group with similar interests in producing such a video. Our project has joined with Pork Central, Alberta Pork, Manitoba Pork, Elanco Animal Health and Pig Improvement Company (PIC) to produce a video that addresses the many issues of pork producers as neighbours. One of the main topics is odour abatement, which fit perfectly into our video development plans. The combined resources and distribution plans of the partnership will ensure a minimum of 200 copies of the final product will be available in Saskatchewan. This will allow for much greater exposure to the odour reduction technologies than producing a video independently. This will however require additional time for coordinating production and final copy is anticipated in early spring 1999.

Included in the video is the economic impact of the pork industry, revival of jobs in rural areas, methods to control odour and how producers are addressing environmental concerns.

Information Database

Initially the AFIF project was to include the development of a listing of scientific literature on swine odour and odour control. This information was to be presented in written form only.

During this same period, the author received a contract from Ontario Pork to develop the "Environmental Issues Resource Centre" a searchable database located on the Internet and complemented with written chapter summaries on the major environmental issues facing the swine industry.

The combined resources of the two projects has allowed for a significant expansion of the literature search on odour. Over 100 papers have been reviewed to-date. These are reduced to abstract form, catalogued and available in an easy-to-use database at the PSC site (http://adminsrv.usask.ca/psci) under the icon 'environmental issues'. This site will be expanded by approximately 30 additional articles through the efforts of the AFIF project. At that time AFIF identification will be added to the site at the odour section to recognize the financial contribution made here.